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PROCEEDINGS

OF

THE AMERICAN ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE,

THIRTY-SEVENTH MEETING,

BOSTON MEDICAL LIBRARY ASS'N
HELD AT
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AUGUST, 1888.

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GENERAL SECRETARY.

C. LEO MEES of Terre Haute, Ind.

SECRETARY OF THE COUNCIL.

FRANK BAKER of Washington.

SECRETARIES OF THE SECTIONS.

A. Mathematics and Astronomy—GEORGE C. COMSTOCK of Madison, Wis.
B. Physics—EDWARD L. NICHOLS of Ithaca, N. Y.
C. Chemistry—EDWARD HART of Easton, Pa.
D. Mechanical Science and Engineering—JAMES E. DENTON of Hoboken, N. J.
E. Geology and Geography—JOHN C. BRANNER of Little Rock, Ark.
F. Biology—AMOS W. BUTLER of Brookville, Ind.
H. Anthropology—WILLIAM M. BEAUCHAMP of Baldwinsville, N. J.
I. Economic Science and Statistics—JOHN R. DODGE of Washington, D. C.

TREASURER.

WILLIAM LILLY of Mauch Chunk, Pa.

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MEETINGS AND OFFICERS OF THE AMERICAN ASSOCIATION OF GEOLOGISTS AND NATURALISTS.

MEETING.	DATE.	PLACE.	CHAIRMAN.	SECRETARY.	ASSIS'T SEC'Y.	TREASURER.
1st	April 2, 1840,	Philadelphia,	Edward Hitchcock,*	L. C. Beck,*		
2d	April 5, 1841,	Philadelphia,	Benjamin Silliman,*	L. C. Beck,*	B. Silliman, jr.,* C. B. Trego,*	
3d	April 25, 1842,	Boston,	S. G. Morton,*	C. T. Jackson,*	J. D. Whitney, M. B. Williams,*	
4th	April 26, 1843,	Albany,	Henry D. Rogers,*	B. Silliman, jr.,*		John Locke.*
5th	May 8, 1844,	Washington,	John Locke,*	B. Silliman, jr.,* O. P. Hubbard,		Douglas Houghton.*
6th	April 30, 1845,	New Haven,	Wm. B. Rogers,*	B. Silliman, jr.,* J. Lawrence Smith,*		Douglas Houghton.*
7th	Sept. 2, 1846,	New York,	C. T. Jackson,*	B. Silliman, jr.,*		E. C. Herrick.*
8th	Sept. 20, 1847,	Boston,	Wm. B. Rogers,†*	Jeffries Wyman,*		B. Silliman. jr.*

* Deceased.

† Professor ROGERS, as chairman of this last meeting, called the first meeting of the new Association to order and presided until it was fully organized by the adoption of a constitution. As he was thus the first presiding officer of the new Association, it was directed at the Hartford meeting that his name be placed at the head of the Past Presidents of the American Association for the Advancement of Science.

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MEETINGS AND OFFICERS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

MEETING.	DATE.	PLACE.	PRESIDENT.	VICE-PRESIDENT.	GENERAL SECRETARY.	PERMANENT SEC'Y.	TREASURER.
1st	Sept. 20, 1848,	Philadelphia, Pa.,	W. C. Redfield,*		Walter R. Johnson,*		Jeffries Wyman.*
2d	Aug. 14, 1849,	Cambridge, Mass.,	Joseph Henry,*		E. N. Horsford, 1		A. L. Elwyn.*
3d	Mar. 12, 1850,	Charleston, S. C.,	A. D. Bache,* 2		L. R. Gibbs, 3		St. J. Ravenel.* 4
4th	Aug. 19, 1850,	New Haven, Conn.,	A. D. Bache,*		E. C. Herrick,*		A. L. Elwyn.*
5th	May 5, 1851,	Cincinnati, Ohio,	A. D. Bache,*		W. B. Rogers, 5*	S. F. Baird,*	S. F. Baird. 6
6th	Aug. 19, 1851,	Albany, N. Y.,	Louis Agassiz,*		W. B. Rogers,*	S. F. Baird,*	A. L. Elwyn.*
7th	July 28, 1853,	Cleveland, Ohio,	Benjamin Pierce,*		S. St. John,* 7	S. F. Baird,*	A. L. Elwyn.*
8th	April 26, 1854,	Washington, D. C.,	J. D. Dana,		J. Lawrence Smith,*	Joseph Lovering,	J. L. LeConte* 8
9th	Aug. 15, 1855,	Providence, R. I.,	John Torrey,*		Wolcott Gibbs,	Joseph Lovering,	A. L. Elwyn.*
10th	Aug. 20. 1856,	Albany, N. Y.,	James Hall,		B. A. Gould,	Joseph Lovering,	A. L. Elwyn.*
11th	Aug. 12, 1857,	Montreal, Canada,	Alexis Caswell,* 9	Alexis Caswell,*	John LeConte,	Joseph Lovering,	A. L. Elwyn.*
12th	April 28, 1858,	Baltimore, Md.,	Alexis Caswell,* 10	John E. Holbrook,*†	W. M. Gillespie,* 11	Joseph Lovering,	A. L. Elwyn.*
13th	Aug. 3, 1859,	Springfield, Mass.,	Stephen Alexander,*	Edward Hitchcock,*	William Chauvenet,*	Joseph Lovering,	A. L. Elwyn.*
14th	Aug. 1, 1860,	Newport, R. I.,	Isaac Lea,*	B. A. Gould,	Joseph LeConte,	Joseph Lovering,	A. L. Elwyn.*
15th	Aug. 15, 1866,	Buffalo, N. Y.,	F. A. P. Barnard,*	A. A. Gould,* 12	Elias Loomis, 13	Joseph Lovering,	A. L. Elwyn.†*
16th	Aug. 21, 1867,	Burlington, Vt.,	J. S. Newberry,	Wolcott Gibbs,	C. S. Lyman,	Joseph Lovering,	A. L. Elwyn.†*
17th	Aug. 5, 1868,	Chicago, Ill.,	B. A. Gould,	Charles Whittlesey,*	Simon Newcomb, 14	Joseph Lovering,	A. L. Elwyn.†*
18th	Aug. 18, 1869,	Salem, Mass.,	J. W. Foster,*	O. N. Rood,	O. C. Marsh,	F. W. Putnam, 15	A. L. Elwyn.†*
19th	Aug. 17, 1870,	Troy, N. Y.,	T. S. Hunt, 16	T. S. Hunt,	F. W. Putnam, 17	Joseph Lovering,	A. L. Elwyn.†*
20th	Aug. 16, 1871,	Indianapolis, Ind.,	Asa Gray,*	G. F. Barker,	F. W. Putnam,	Joseph Lovering,	W. S. Vaux.*
21st	Aug. 15, 1872,	Dubuque, Iowa,	J. Lawrence Smith,*	Alex. Winchell,	E. S. Morse,	Joseph Lovering,	W. S. Vaux.*
22d	Aug. 20, 1873,	Portland, Me.,	Joseph Lovering,	A. H. Worthen,†*	C. A. White,	F. W. Putnam,	W. S. Vaux.*
23d	Aug. 12, 1874,	Hartford, Conn.,	J. L. LeConte,*	C. S. Lyman,	A. C. Hamlin,	F. W. Putnam,	W. S. Vaux.†*

1. In place of Jeffries Wyman, *not present.*
2. In place of Joseph Henry, *not present.*
3. In place of E. C. Herrick, *not present.*
4. In place of A. L. Elwyn, *not present.*
5. In place of E. C. Herrick, *not present.*
6. In place of A. L. Elwyn, *not present.*
7. In place of J. D. Dana, *not present.*
8. In place of A. L. Elwyn, *not present.*
9. In place of J. W. Bailey, *deceased.*
10. In place of Jeffries Wyman, *not present.*
11. In place of Wm. Chauvenet, *not present.*
12. In place of R. W. Gibbes, *not present.*
13. In place of W. P. Trowbridge, *not present.*
14. In place of A. P. Rockwell, *called home 1st day.*
15. In place of Joseph Lovering, *in Europe.*
16. In place of Wm. Chauvenet, *too ill to be present.*
17. In place of C. F. Hartt, *in Brazil.*

* Deceased. † Not present at the meeting.

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MEETINGS AND OFFICERS OF THE ASSOCIATION (*Continued*).

MEETING.	DATE.	PLACE.	PRESIDENT.	VICE PRESIDENT, SECTION A.	VICE PRESIDENT, SECTION B.	CHAIRMAN OF PERMANENT SUBSECTION OF CHEMISTRY.	CHAIRMAN OF PERMANENT SUBSECTION OF ANTHROPOLOGY.	CHAIRMAN OF PERMANENT SUBSECTION OF MICROSCOPY.	CHAIRMAN OF PERMANENT SUBSECTION OF ENTOMOLOGY.
24th	Aug. 11, 1875.	Detroit, Mich.,	J. E. Hilgard,	H. A. Newton,	J. W. Dawson,	S. W. Johnson,	L. H. Morgan,*	———	———
25th	Aug. 23, 1876.	Buffalo, N. Y.,	W. B. Rogers,*	C. A. Young,	E. S. Morse,	G. F. Barker,	L. H. Morgan,*	R. H. Ward,	———
26th	Aug. 29, 1877.	Nashville, Tenn.,	S. Newcomb,	R. H. Thurston,[1]	O. C. Marsh,	N. T. Lupton,	Daniel Wilson,†	R. H. Ward,	———
27th	Aug. 21, 1878.	St. Louis, Mo.,	O. C. Marsh,	R. H. Thurston,	Aug. R. Grote,	F. W. Clarke,	———[2]	R. H. Ward,[3]	———
28th	Aug. 27, 1879.	Saratoga, N. Y.,	G. F. Barker,	S. P. Langley,	J. W. Powell,	F. W. Clarke,[4]	Daniel Wilson,	E. W. Morley,	———
29th	Aug. 25, 1880.	Boston, Mass.,	L. H. Morgan,*	Asaph Hall,	Alex. Agassiz,	J. M. Ordway,	J. W. Powell,	S. A. Lattimore,	———
30th	Aug. 17, 1881.	Cincinnati, Ohio,	G. J. Brush,	Wm. Harkness,[7]	E. T. Cox,[8]	G. C. Caldwell,[9]	G. Mallery,	A. B. Hervey,	J. G. Morris.

PERMANENT SECRETARY.	GENERAL SECRETARY.	SECRETARY OF SECTION A.	SECRETARY OF SECTION B.	SECRETARY OF PERMANENT SUBSECTION OF CHEMISTRY.	SECRETARY OF PERMANENT SUBSECTION OF ANTHROPOLOGY.	SECRETARY OF PERMANENT SUBSECTION OF MICROSCOPY.	SECRETARY OF PERMANENT SUBSECTION OF ENTOMOLOGY.	TREASURER.
F. W. Putnam,	S. H. Scudder,	S. P. Langley, T. C. Mendenhall,	E. S. Morse,	F. W. Clarke,	F. W. Putnam,	———	———	W. S. Vaux,*
F. W. Putnam,	T. C. Mendenhall,	A. W. Wright,	Albert H. Tuttle,	H. C. Bolton,	O. T. Mason,	E. W. Morley,	———	W. S. Vaux,*
F. W. Putnam,	Aug. R. Grote,	H. C. Bolton,	Wm. H. Dall,	P. Schweitzer,	———[2]	T. O. Summers, jr.,	———	W. S. Vaux,†*
F. W. Putnam,	H. C. Bolton,	F. E. Nipher,	George Little,	A. P. S. Stuart,	———[2]	G. J. Engelmann,	———	W. S. Vaux,†*
F. W. Putnam,	H. C. Bolton,[5]	J. K. Rees,	W. H. Dall,[6]	W. R. Nichols,*	J. G. Henderson,	A. B. Hervey,	———	W. S. Vaux,†*
F. W. Putnam,	J. K. Rees,	H. B. Mason,	C. V. Riley,	C. E. Munroe,	J. G. Henderson,	A. B. Hervey,	———	W. S. Vaux,*
F. W. Putnam,	C. V. Riley,	E. T. Tappan,[10]	Wm. Saunders,	A. Springer,[12]	J. G. Henderson,	W. H. Seaman,[11]	B. P. Mann,	W. S. Vaux,†*

[1] In the absence of E. C. Pickering.
[2] The Subsection united with Sec. B.
[3] In the absence of G. S. Blackie.
[4] In the absence of Ira Remsen.
[5] In the absence of George Little.
[6] In the absence of A. C. Wetherby.
[7] In the absence of A. M. Mayer.
[8] In the absence of George Engelmann.
[9] In the absence of W. R. Nichols.
[10] In the absence of John Trowbridge.
[11] In the absence of S. P. Sharples.
[12] In place of H. W. Wiley, called away.
* Deceased.
† Not present.

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MEETING.	DATE.	PLACE.	PRESIDENT.	VICE PRESIDENTS.				
				Section A.	Section B.	Section C.	Section D.	Section E.
31st	Aug. 23, 1882.	Montreal, Can.	J. W. Dawson,	W. A. Rogers,[1]	T.C. Mendenhall,	H. C. Bolton,	W. P. Trowbridge,	E. T. Cox,
32nd	Aug. 15, 1883.	Minneapolis, M.	C. A. Young,	W. A. Rogers,	H. A. Rowland,	E. W. Morley,	De Volsen Wood,[7]	C.H. Hitchcock,
33rd	Sept. 3, 1884.	Philadelphia, Pa.	J. P. Lesley.	H. T. Eddy,	J. Trowbridge.	J. W. Langley,	R. H. Thurston,	N. H. Winchell,
34th	Aug. 26, 1885.	Ann Arbor, Mich.	H. A. Newton,	W. Harkness,[15]	S. P. Langley,[16]	N. T. Lupton,[17]	J. Burkitt Webb,	Edward Orton,
35th	Aug. 18, 1886.	Buffalo, N. Y.	E. S. Morse,	J. W. Gibbs,	C. F. Brackett,	H. W. Wiley,	O Chanute,	T. C Chamberlin,
36th	Aug. 10, 1887.	New York,	S. P. Langley,	J.R. Eastman,[26]	W. A. Anthony,	A. B. Prescott	E. B. Coxe,	G. K. Gilbert,

VICE PRESIDENTS.				Permanent Secretary.	General Secretary.	Assistant Gen. Secretary.	SECRETARIES OF SECTIONS.	
Section F.	Section G.	Section H.	Section I.				Section A.	Section B.
W. H. Dall,	A. H. Tuttle,	Alex. Winchell,[2]	E. B. Elliott,	F. W. Putnam,	Wm. Saunders,	J. R. Eastman,	H. T. Eddy,	C. S. Hastings,
W. J. Beal,	J. D. Cox.	O. T. Mason,	F. B. Hough,*	F. W. Putnam,	J. R. Eastman.	Alfred Springer,	G. W. Hough,[8]	F. E. Nipher.[9]
E. D. Cope.	T. G. Wormley,	E. S. Morse,	John Eaton,	F. W. Putnam,	Alfred Springer,	C. S. Minot,[12]	G. W. Hough,	N. D. C. Hodges,
T. J. Burrill,[18]	S. H. Gage,	J. O. Dorsey,[19]	Edw. Atkinson	F. W. Putnam,	C. S. Minot,	S. G. Williams,[20]	E. W. Hyde.	B. F. Thomas,[21]
H. P. Bowditch,	——[25]	H. Hale,	Jos. Cummings	F. W. Putnam,	S. G. Williams,	W. H. Pettee,	S. C. Chandler,	H. S. Carhart,
W. G. Farlow,	——	D. G. Brinton,	H. E. Alvord,	F. W. Putnam.	W. H. Pettee,	J. C. Arthur,	H. M. Paul,	C. Leo Mees,

SECRETARIES OF THE SECTIONS.							Treasurer.
Section C.	Section D.	Section E.	Section F.	Section G.	Section H.	Section I.	
Alfred Springer,	J. B. Webb,[3]	H. S. Williams,[4]	Wm. Osler,[5]	Robt. Brown, jr.,	O. T. Mason.	F. B. Hough,[6*]	——*
J. W. Langley,[10]	J. B. Webb,[11]	A. A. Julien,	S. A. Forbes,	Carl Seiler,	G. H. Perkins,	Jos. Cummings,	William Lilly.
H. Carmichael,[13]	J. B. Webb,	E. A. Smith.	C. E. Bessey,	R. Hitchcock,	G. H. Perkins,[14]	C. W. Smiley,	William Lilly.
F.P. Dunnington,	C. J. H. Woodbury,	G. K. Gilbert,[22]	J. A. Lintner,[23]	W. H. Walmsley,	Erm. A. Smith,[3]	C. W. Smiley,[24]	William Lilly.
W. McMurtrie,	William Kent,	E. W. Claypole,	J. C. Arthur,	——[25]	A. W. Butler,	H. E. Alvord.	William Lilly.
C. S. Mabery,[27]	G. M. Bond,	W. M. Davis,[28]	J. H. Comstock,	——	C. C. Abbott,[29]	W. R. Lazenby,	William Lilly.

1 In the absence of William Harkness.
2 In the absence of Daniel Wilson.
3 In the absence of C. B. Dudley.
4 In the absence of C. E. Dutton.
5 In the absence of C. S. Minot.
6 F. B. Hough was called home and J. R. Dodge acted at the close of the meeting.
7 Absent but place was not filled.
8 In the absence of W. W. Johnson.
9 In the absence of C. K. Wead.
10 W. M. McMurtrie, last three days of meeting.
11 Pro tempore.
12 In the absence of E. S. Holden.
13 In the absence of R. B. Warder.
14 In the absence of W. H. Holmes.
15 In the absence of J. M. Van Vleck.
16 In place of C. F. Brackett, resigned.
17 In the absence of W. K. Nichols.
18 In the absence of B. G. Wilder.
19 In the absence of W. H. Dall.
20 In place of C. C. Abbott, not present
21 In place of A.A. Michelson, resigned.
22 In the absence of H. C. Lewis.
23 In place of C. H. Fernald, resigned.
24 In the absence of J. W. Chickering.
25 Section permanently united to Section F.
26 In place of W. Ferrel, resigned.
27 Absent; B. B. Warder acted as Sec'y pro tem.
28 In place of T. B. Comstock, absent.
29 In place of F. W. Langdon, absent.
*Deceased.

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MEETINGS AND OFFICERS OF THE ASSOCIATION (*Continued*).

MEETING.	DATE.	PLACE.	PRESIDENT.
37th.	Aug. 15, 1888.	Cleveland, Ohio.	J. W. Powell.

VICE PRESIDENTS.

SECTION A.	SECTION B.	SECTION C.	SECTION D.
Ormond Stone.	A. A. Michelson.	C. E. Munroe.	C. J. H. Woodbury.

SECTION E.	SECTION F.	SECTION H.	SECTION I.
George H. Cook.	C. V. Riley.	C. C. Abbott.	C. W. Smiley.

PERMANENT SECRETARY.	GENERAL SECRETARY.	SECRETARY OF COUNCIL.	TREASURER.
F. W. Putnam.	Julius Pohlman.	C. Leo Mees.	William Lilly.

SECRETARIES OF SECTIONS.

SECTION A.	SECTION B.	SECTION C.	SECTION D.
C. C. Doolittle.	A. Macfarlane.	W. L. Dudley.	Arthur Beardsley.

SECTION E.	SECTION F.	SECTION H.	SECTION I.
John C. Branner.	B. H. Fernow.	Frank Baker.	Charles S. Hill.

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MEETINGS.	PLACE.	YEAR.	MEMBERS IN ATTENDANCE.	NUMBER OF MEMBERS.
1.	Philadelphia	1848	?	461
2.	Cambridge	1849	?	540
3.	Charleston	1850	?	682
4.	New Haven	1850	?	704
5.	Cincinnati	1851	87	800
6.	Albany	1851	194	769
7.	Cleveland	1853	?	940
8.	Washington	1854	168	1004
9.	Providence	1855	166	605
10.	2nd Albany	1856	381	722
11.	Montreal	1857	351	946
12.	Baltimore	1858	190	962
13.	Springfield	1859	190	862
14.	Newport	1860	135	644
15.	Buffalo	1866	79	637
16.	Burlington	1867	73	415
17.	Chicago	1868	259	686
18.	Salem	1869	244	511
19.	Troy	1870	188	536
20.	Indianapolis	1871	196	668
21.	Dubuque	1872	164	610
22.	Portland	1873	195	670
23.	Hartford	1874	224	722
24.	Detroit	1875	165	807
25.	2nd Buffalo	1876	215	867
26.	Nashville	1877	173	953
27.	St. Louis	1878	134	962
28.	Saratoga	1879	256	1030
29.	Boston	1880	997	1555
30.	2nd Cincinnati	1881	500	1699
31.	2nd Montreal	1882	937	1922
32.	Minneapolis	1883	328	2033
33.	2nd Philadelphia	1884	1261*	1981
34.	Ann Arbor	1885	364	1956
35.	3d Buffalo	1886	445	1886
36.	New York	1887	729	1956
37.	2nd Cleveland	1888	342	1964
38.	Toronto	1889	——	——

*Including members of the British Association and other foreign guests.

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COMMONWEALTH OF MASSACHUSETTS.

IN THE YEAR ONE THOUSAND EIGHT HUNDRED AND SEVENTY-FOUR.

AN ACT

To Incorporate the "American Association for the Advancement of Science."

Be it enacted by the Senate and House of Representatives, in General Court assembled, and by the authority of the same, as follows:

Section 1. Joseph Henry of Washington, Benjamin Pierce of Cambridge, James D. Dana of New Haven, James Hall of Albany, Alexis Caswell of Providence, Stephen Alexander of Princeton, Isaac Lea of Philadelphia, F. A. P. Barnard of New York, John S. Newberry of Cleveland, B. A. Gould of Cambridge, T. Sterry Hunt of Boston, Asa Gray of Cambridge, J. Lawrence Smith of Louisville, Joseph Lovering of Cambridge and John LeConte of Philadelphia, their associates, the officers and members of the Association, known as the "American Association for the Advancement of Science," and their successors, are hereby made a corporation by the name of the "American Association for the Advancement of Science," for the purpose of receiving, purchasing, holding and conveying real and personal property, which it now is, or hereafter may be, possessed of, with all the powers and privileges, and subject to the restrictions, duties and liabilities set forth in the general laws which now or hereafter may be in force and applicable to such corporations.

Section 2. Said corporation may have and hold by purchase, grant, gift or otherwise, real estate not exceeding one hundred thousand dollars in value, and personal estate of the value of two hundred and fifty thousand dollars.

Section 3. Any two of the corporators above named are hereby authorized to call the first meeting of the said corporation in the month of August next ensuing, by notice thereof "by mail," to each member of the said Association.

Section 4. This act shall take effect upon its passage.

House of Representatives, March 10, 1874.
Passed to be enacted,
John E. Sanford, *Speaker.*

In Senate, March 17, 1874.
Passed to be enacted,
Geo. B. Loring, *President.*

March 19, 1874.
Approved,
W. B. Washburn.

Secretary's Department,
Boston, April 3, 1874.
A true copy, Attest:
David Pulsifer,
Deputy Secretary of the Commonwealth.

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CONSTITUTION

OF THE

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Incorporated by Act of the General Court of the Commonwealth of Massachusetts.

OBJECTS.

ARTICLE 1. The objects of the Association are, by periodical and migratory meetings, to promote intercourse between those who are cultivating science in different parts of America, to give a stronger and more general impulse and more systematic direction to scientific research, and to procure for the labors of scientific men increased facilities and a wider usefulness.

MEMBERS, FELLOWS, PATRONS AND HONORARY FELLOWS.

ART. 2. The Association shall consist of Members, Fellows, Patrons, and Honorary Fellows.

ART. 3. Any person may become a Member of the Association upon recommendation in writing by two members or fellows, and election by the Council.

ART. 4. Fellows shall be elected by the Council from such of the members as are professionally engaged in science, or have by their labors aided in advancing science. The election of fellows shall be by ballot and a majority vote of the members of the Council at a designated meeting of the Council.

ART. 5. Any person paying to the Association the sum of one thousand dollars shall be classed as a Patron, and shall be entitled to all the privileges of a member and to all its publications.

ART. 6. Honorary Fellows of the Association, not exceeding three for each section, may be elected; the nominations to be made by the Council and approved by ballot in the respective sections before election by ballot in General Session. Honorary Fellows shall be entitled to all the privi-

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leges of Fellows and shall be exempt from all fees and assessments, and entitled to all publications of the Association issued after the date of their election.

ART. 7. The name of any member or fellow two years in arrears for annual dues shall be erased from the list of the Association, provided that two notices of indebtedness, at an interval of at least three months, shall have been given; and no such person shall be restored until he has paid his arrearages or has been reëlected. The Council shall have power to exclude from the Association any member or fellow, on satisfactory evidence that said member or fellow is an improper person to be connected with the Association, or has in the estimation of the Council made improper use of his membership or fellowship.

ART. 8. No member or fellow shall take part in the organization of, or hold office in, more than one section at any one meeting.

OFFICERS.

ART. 9. The Officers of the Association shall be elected by ballot in General Session from the fellows, and shall consist of a President, a Vice President from each section, a Permanent Secretary, a General Secretary, a Secretary of the Council, a Treasurer, and a Secretary of each Section; these, with the exception of the Permanent Secretary, shall be elected at each meeting for the following one, and, with the exception of the Treasurer and the Permanent Secretary, shall not be reëligible for the next two meetings. The term of office of Permanent Secretary shall be five years.

ART. 10. The President, or, in his absence, the senior Vice President present, shall preside at all General Sessions of the Association and at all meetings of the Council. It shall also be the duty of the President to give an address at a General Session of the Association at the meeting following that over which he presided.

ART. 11. The Vice Presidents shall be the chairmen of their respective Sections, and of their Sectional Committees, and it shall be part of their duty to give an address, each before his own section, at such time as the Council shall determine. The Vice Presidents may appoint temporary chairmen to preside over the sessions of their sections, but shall not delegate their other duties. The Vice Presidents shall have seniority in order of their continuous membership in the Association.

ART. 12. The General Secretary shall be the Secretary of all General Sessions of the Association, and shall keep a record of the business of

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these sessions. He shall receive the records from the Secretaries of the Sections, which, after examination, he shall transmit with his own records to the Permanent Secretary within two weeks after the adjournment of the meeting.

ART. 13. The Secretary of the Council shall keep the records of the Council. He shall give to the Secretary of each Section the titles of papers assigned to it by the Council. He shall receive proposals for membership and bring them before the Council.

ART. 14. The Permanent Secretary shall be the executive officer of the Association under the direction of the Council. He shall attend to all business not specially referred to committees nor otherwise constitutionally provided for. He shall keep an account of all business that he has transacted for the Association, and make annually a general report for publication in the annual volume of Proceedings. He shall attend to the printing and distribution of the annual volume of Proceedings, and all other printing ordered by the Association. He shall issue a circular of information to members and fellows at least three months before each meeting, and shall, in connection with the Local Committee, make all necessary arrangements for the meetings of the Association. He shall provide the Secretaries of the Association with such books and stationery as may be required for their records and business, and shall provide members and fellows with such blank forms as may be required for facilitating the business of the Association. He shall collect all assessments and admission fees, and notify members and fellows of their election, and of any arrearages. He shall receive, and bring before the Council, the titles and abstracts of papers proposed to be read before the Association. He shall keep an account of all receipts and expenditures of the Association, and report the same annually at the first meeting of the Council, and shall pay over to the Treasurer such unexpended funds as the Council may direct. He shall receive and hold in trust for the Association all books, pamphlets and manuscripts belonging to the Association, and allow the use of the same under the provisions of the Constitution and the orders of the Council. He shall receive all communications addressed to the Association during the interval between meetings, and properly attend to the same. He shall at each meeting report the names of fellows and members who have died since the preceding meeting. He shall be allowed a salary which shall be determined by the Council, and may employ one or more clerks at such compensation as may be agreed upon by the Council.

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ART. 15. The Treasurer shall invest the funds received by him in such securities as may be directed by the Council. He shall annually present to the Council an account of the funds in his charge. No expenditure of the principal in the hands of the Treasurer shall be made without a unanimous vote of the Council, and no expenditure of the income received by the Treasurer shall be made without a two-thirds vote of the Council.

ART. 16. The Secretaries of the Sections shall keep the records of their respective sections, and, at the close of the meeting, give the same, including the records of subsections, to the General Secretary. They shall also be the Secretaries of the Sectional Committees. The Secretaries shall have seniority in order of their continuous membership in the Association.

ART. 17. In case of a vacancy in the office of the President, one of the Vice Presidents shall be elected by the Council as the President of the meeting. Vacancies in the offices of Vice President, Permanent Secretary, General Secretary, Secretary of the Council, and Treasurer, shall be filled by nomination of the Council and election by ballot in General Session. A vacancy in the office of Secretary of a Section shall be filled by nomination and election by ballot in the Section.

ART. 18. The Council shall consist of the past Presidents, and the Vice Presidents of the last meeting, together with the President, the Vice Presidents, the Permanent Secretary, the General Secretary, the Secretary of the Council, the Secretaries of the Sections, and the Treasurer of the current meeting, with the addition of one fellow elected from each Section by ballot on the first day of its meeting. The members present at any regularly called meeting of the Council, provided there are at least five, shall form a quorum for the transaction of business. The Council shall meet on the day preceding each annual meeting of the Association, and arrange the programme for the first day of the sessions. The time and place of this first meeting shall be designated by the Permanent Secretary. Unless otherwise agreed upon, regular meetings of the Council shall be held in the council room at 9 o'clock, A.M., on each day of the meeting of the Association. Special meetings of the Council may be called at any time by the President. The Council shall be the board of supervision of the Association, and no business shall be transacted by the Association that has not first been referred to, or originated with, the Council. The Council shall receive and assign papers to the respective sections; examine and, if necessary, exclude papers; decide which papers,

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discussions and other proceedings shall be published, and have the general direction of the publications of the Association; manage the financial affairs of the Association; arrange the business and programmes for General Sessions; suggest subjects for discussion, investigation or reports; elect members and fellows; and receive and act upon all invitations extended to the Association and report the same at a General Session of the Association. The Council shall receive all reports of Special Committees and decide upon them, and only such shall be read in General Session as the Council shall direct. The Council shall appoint at each meeting the following sub-committees who shall act, subject to appeal to the whole Council, until their successors are appointed at the following meeting: 1, on Papers and Reports; 2, on Members; 3, on Fellows.

ART. 19. The Nominating Committee shall consist of the Council, and one member or fellow elected by each of the Sections. It shall be the duty of this Committee to meet at the call of the President and nominate the general officers for the following meeting of the Association. It shall also be the duty of this Committee to recommend the time and place for the next meeting. The Vice President and Secretary of each Section shall be recommended to the Nominating Committee by a sub-committee consisting of the Vice President, Secretary, and three members or fellows elected by the Section.

MEETINGS.

ART. 20. The Association shall hold a public meeting annually, for one week or longer, at such time and place as may be determined by vote of the Association, and the preliminary arrangements for each meeting shall be made by the Local Committee, in conjunction with the Permanent Secretary and such other persons as the Council may designate.

ART. 21. A General Session shall be held at 10 o'clock A. M., on the first day of the meeting, and at such other times as the Council may direct.

SECTIONS AND SUBSECTIONS.

ART. 22. The Association shall be divided into Sections, namely:—A, *Mathematics and Astronomy*; B, *Physics*; C, *Chemistry, including its application to agriculture and the arts*; D, *Mechanical Science and Engineering*; E, *Geology and Geography*; F, *Biology*; [G, united to section F]; H, *Anthropology*; I, *Economic Science and Statistics*. The Council shall have power to consolidate any two or more Sections temporarily, and such consolidated Sections shall be presided over by the senior Vice President and Secretary of the Sections comprising it.

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ART. 23. Immediately on the organization of a Section there shall be three fellows elected by ballot after open nomination, who, with the Vice President and Secretary, shall form its Sectional Committee. The Sectional Committees shall have power to fill vacancies in their own numbers. Meetings of the Sections shall not be held at the same time with a General Session.

ART. 24. The Sectional Committee of any Section may at its pleasure form one or more temporary Subsections, and may designate the officers thereof. The Secretary of a Subsection shall, at the close of the meeting, transmit his records to the Secretary of the Section.

ART. 25. A paper shall not be read in any Section or Subsection until it has been received from the Council and placed on the programme of the day by the Sectional Committee.

SECTIONAL COMMITTEES.

ART. 26. The Sectional Committees shall arrange and direct the business of their respective Sections. They shall prepare the daily programmes and give them to the Permanent Secretary for printing at the earliest moment practicable. No titles of papers shall be entered on the daily programmes except such as have passed the Council. No change shall be made in the programme for the day in a Section without the consent of the Sectional Committee. The Sectional Committees may refuse to place the title of any paper on the programme; but every such title, with the abstract of the paper or the paper itself, must be returned to the Council with the reasons why it was refused.

ART. 27. The Sectional Committees shall examine all papers and abstracts referred to the sections, and they shall not place on the programme any paper inconsistent with the character of the Association; and to this end they have power to call for any paper, the character of which may not be sufficiently understood from the abstract submitted.

PAPERS AND COMMUNICATIONS.

ART. 28. All members and fellows must forward to the Permanent Secretary, as early as possible, and when practicable before the convening of the Association, full titles of all the papers which they propose to present during the meeting, with a statement of the time that each will occupy in delivery, and also such abstracts of their contents as will give a general idea of their nature; and no title shall be referred by the Council to the Sectional Committee until an abstract of the paper or the paper itself has been received.

ART. 29. If the author of any paper be not ready at the time assigned, the title may be dropped to the bottom of the list.

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ART. 30. Whenever practicable, the proceedings and discussions at General Sessions, Sections and Subsections shall be reported by professional reporters, but such reports shall not appear in print as the official reports of the Association unless revised by the Secretaries.

PRINTED PROCEEDINGS.

ART. 31. The Permanent Secretary shall have the Proceedings of each meeting printed in an octavo volume as soon after the meeting as possible, beginning one month after adjournment. Authors must prepare their papers or abstracts ready for the press, and these must be in the hands of the Secretaries of the Sections before the final adjournment of the meeting, otherwise only the titles will appear in the printed volume. The Council shall have power to order the printing of any paper by abstract or title only. Whenever practicable, proofs shall be forwarded to authors for revision. If any additions or substantial alterations are made by the author of a paper after its submission to the Secretary, the same shall be distinctly indicated. Illustrations must be provided for by the authors of the papers, or by a special appropriation from the Council. Immediately on publication of the volume, a copy shall be forwarded to every member and fellow of the Association who shall have paid the assessment for the meeting to which it relates, and it shall also be offered for sale by the Permanent Secretary at such price as may be determined by the Council. The Council shall also designate the institutions to which copies shall be distributed.

LOCAL COMMITTEE.

ART. 32. The Local Committee shall consist of persons interested in the objects of the Association and residing at or near the place of the proposed meeting. It is expected that the Local Committee, assisted by the officers of the Association, will make all essential arrangements for the meeting, and issue a circular giving necessary particulars, at least one month before the meeting.

LIBRARY OF THE ASSOCIATION.

ART. 33. All books and pamphlets received by the Association shall be in the charge of the Permanent Secretary, who shall have a list of the same printed and shall furnish a copy to any member or fellow on application. Members and fellows who have paid their assessments in full shall be allowed to call for books and pamphlets, which shall be delivered to them at their expense, on their giving a receipt agreeing to make good any loss or damage and to return the same free of expense to the Secretary at the time specified in the receipt given. All books and pamphlets

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in circulation must be returned at each meeting. Not more than five books, including volumes, parts of volumes, and pamphlets, shall be held at one time by any member or fellow. Any book may be withheld from circulation by order of the Council.

Admission Fee and Assessments.

Art. 34. The admission fee for members shall be five dollars in addition to the annual assessment. On the election of any member as a fellow an additional fee of two dollars shall be paid.

Art. 35. The annual assessment for members and fellows shall be three dollars.

Art. 36. Any member or fellow who shall pay the sum of fifty dollars to the Association, at any one time, shall become a Life Member and as such shall be exempt from all further assessments, and shall be entitled to the Proceedings of the Association. All money thus received shall be invested as a permanent fund, the income of which, during the life of the member, shall form a part of the general fund of the Association; but, after his death, shall be used only to assist in original research, unless otherwise directed by unanimous vote of the Council.

Art. 37. All admission fees and assessments must be paid to the Permanent Secretary, who shall give proper receipts for the same.

Accounts.

Art. 38. The accounts of the Permanent Secretary and of the Treasurer shall be audited annually, by Auditors appointed by the Council.

Alterations of the Constitution.

Art. 39. No part of this Constitution shall be amended or annulled, without the concurrence of three-fourths of the members and fellows present in General Session, after notice given at a General Session of a preceding meeting of the Association.

ORDER OF PROCEEDINGS IN ORGANIZING A MEETING.

1. The retiring President introduces the President elect, who takes the chair.
2. Formalities of welcome of the Association as may be arranged by the Local Committee.
3. Report of the list of papers entered and their reference to the Sections.
4. Other reports.
5. Announcements of arrangements by the Local Committee.
6. Announcements of Elections by the Council.
7. Unenumerated business.
8. Adjournment to meet in Sections.

This order, so far as applicable, to be followed in subsequent General Sessions.

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MEMBERS

OF THE

AMERICAN ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE.[1]

PATRONS.[2]

THOMPSON, MRS. ELIZABETH, Stamford, Conn. (22).
LILLY, GEN. WILLIAM, Mauch Chunk, Carbon Co., Pa. (28) F E
HERRMAN, MRS. ESTHER, 59 West 56th St., New York, N. Y. (29).

MEMBERS.[3]

Abbe, Robert, 11 W. 50th St., New York, N. Y. (36).
Abert, S. Thayer, 810 19th St., N. W., Washington, D. C. (30). A B D E I
Adams, W. H., Consulting Engineer, 71 Wall St., New York, N. Y. (36).
Agard, Dr. A. H., 1259 Alice St., Oakland, Alameda Co., Cal. (28).
Aher, Mrs. Mary R. Alling, Waterbury, Conn. (29). E F C
Alberger, Louis R., P. O. Box 2227, New York, N. Y. (35). C
Alden, Jno., Pacific Mills, Lawrence, Mass. (36).

[1] The numbers in parentheses indicate the meeting at which the member was elected. The black letters at the end of line indicate the sections to which members elect to belong. The Constitution requires that the names of all members two or more years in arrears shall be omitted from the list, but their names will be restored on payment of arrearages. Members not in arrears are entitled to the annual volume of Proceedings bound in paper. *The payment of ten dollars at one time entitles a member to the subsequent volumes to which he may be entitled, bound in cloth, or by the payment of twenty dollars, to such volumes bound in half morocco.*

[2] Persons contributing one thousand dollars or more to the Association are classed as Patrons, and are entitled to the privileges of members and to the publications.

The names of Patrons are to remain permanently on the list.

[3] Any Member or Fellow may become a Life Member by the payment of fifty dollars. The income of the money derived from a Life Membership is used for the general purposes of the Association during the life of the member; afterwards it is to be used to aid in original research. Life Members are exempt from the annual assessment, and are entitled to the annual volume. The names of Life Members are printed in small capitals in the regular list of Members and Fellows.

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Allderdice, Wm. H., U. S. S. Lancaster, care B. F. Stevens, 4 Trafalgar Square, Charing Cross, London, Eng. (33). D
Allen, Addison, 50 Wall St., New York, N. Y. (36).
Allen, Dudley P., 177 Euclid Ave., Cleveland, Ohio (36) F
Allen, J. M., Hartford, Conn. (22). D
Allen, W. F., 46 Bond St., New York, N. Y. (36).
Alvord, Benjamin, 2nd Lt., U. S. A., West Point, N. Y. (33). A
Ammidown, Edward H., P. O. Box 2739, New York, N. Y. (37).
Anderson, Newton M., 371 Sibley St., Cleveland, Ohio (30). B
Angell, Geo. W. J., 44 Hudson St., New York, N. Y. (36).
Ansley, Clark F., Swedona, Mercer Co., Ill. (32). E H
Appleton, Rev. Edw. W., D.D., Ashbourne P. O., Montgomery Co., Pa. (28).
Archambault, U. E., P. O. box 1944, Montreal, Can. (31).
Arey, Albert L., Free Academy, Rochester, N. Y. (35). B C
Arms, Walter F., Punxsutawney, Jefferson Co., Pa. (35).
Atkinson, Jno. B., Earlington, Hopkins Co., Ky. (26). D
Atterbury, Rev. Anson Phelps, 117 W. 87th St., New York, N. Y. (36). E
Atwell, Charles B., 461 Emerson St., Evanston, Ill. (36). F
Atwood, E. S., East Orange, N. J. (29). F
Austin, Wm., 65 Union Place, New York, N. Y. (36).
Avery, Elroy, M., Ph. D., Woodland Hills Ave.. Cleveland, Ohio (37). B
Avery, Samuel P., 4 E. 38th St., New York, N. Y. (36).
Ayer, Edward Everett, 234, S. Water St., Chicago, Ill. (37). H

Baba, Tatui, 126 W. 42nd St., New York, N. Y. (36). H
Babcock, Geo. H., 30 Cortlandt St., New York, N. Y. (33). D
Bacon, Prof. Chas. A., Observatory Beloit College, Beloit, Wis. (36) A
Bailey, E. H. S., Lawrence, Douglas Co., Kan. (25). C E
Baker, Richard D., 1414 Arch St., Philadelphia, Pa. (33). E C
Baker, Wm. G., 234 E. 15th St., New York, N. Y. (36).
Balderston, C. Canby, Westtown, Chester Co., Pa. (33). B
Baldwin, Judge Charles C., 1264 Euclid Ave., Cleveland, Ohio (37). H I
Baldwin, Miss Mary A., 41 Fulton St., Newark, N. J. (31). E
Baldwin, Mrs. G. H., 3 Madison Ave., Detroit, Mich. (34). H
Ballard, Harlan H., 50 South St., Pittsfield, Mass. (31). E F
Balliard, Chas., Metropolitan Museum of Art, New York, N. Y. (36).
Banes, Charles H., 2021 Spring Garden St., Philadelphia, Pa. (31). D
Bangs, Lemuel Bolton, M.D., 127 E. 34th St., New York, N. Y. (36).
Barber, D. H., Marion, Iowa (37).
Barber, John N., 1317 Hennepin Ave., Minneapolis, Minn. (33). F
Barclay, Robert, A.M., M.D., 3211 Lucas Ave., St. Louis, Mo. (30).
Bardeen, Francis L., M.D., Box 76, Onondaga Hill, N. Y. (32). C F B
Barge, B. F., Mauch Chunk, Pa. (33).
Barker, Mrs. Martha M., 26 Eleventh St., Lowell, Mass. (31). E H
Barnett, J. Davis, Port Hope, Ontario, Can. (34). D B
Barnum, Miss Charlotte C., 144 Humphrey St., New Haven, Conn. (36). A
Barnum, Thomas R., 144 Humphrey St., New Haven, Conn. (35). E

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Barrett, Dwight H., B. & O. R. R. Co., Baltimore, Md. (36).
Bartlett, John W., M.D., 149 W. 94th St., New York, N. Y. (36).
Bartley, Elias H., M.D., 21 Lafayette Ave., Brooklyn, N. Y. (33). C
Bassett, Norman C., Mechanical Engineer, Hale Elevator Co., Room 81, 187 La Salle St., Chicago. Ill. (35). D
Battershall, Jesse Park, 402 Washington St., New York, N. Y. (36).
Battle, Herbert B., N. C. Agric. Exper. Station, Raleigh, N. C. (33). C
Baur, George, New Haven, Conn. (36).
Baxter, James N., 18 Fulton St., Brooklyn, N. Y. (36).
Baxter, Sylvester, office of the Herald, Boston, Mass. (36). H
Beach, William H., Madison, Wis. (21). E B
Bean, Thos. E., Box 441, Galena, Ill. (28). F
Beardslee, H. C., 801 Wilson Ave., Cleveland, Ohio. (37). F
Bechdolt, Adolphus F., Supt. City Schools, Mankato, Minn. (32). E B F
Becker, Dr. Geo. F., U. S. Geol. Survey, San Francisco, Cal. (36). E
Belknap, Morris B., Louisville, Ky. (29). H E
Belknap, Wm. B., Louisville, Ky. (29). D
Bell, C. M., M.D., 320 Fifth Ave., New York, N. Y. (36).
Benjamin, E. B., 6 Barclay St., New York, N. Y. (19). B C
Bennett, Prof. Wm. Z., Wooster, Wayne Co., Ohio (33). C
Beveridge, David, 145 Griswold St., Detroit, Mich. (33). I
Bien, Julius, 139 Duane St., New York, N. Y. (34). E H
Bigelow, Otis, 605 7th St., Washington, D. C. (30). H F
Bigelow, Robert P., Washington, D. C. (32). F E
Bill, Charles, Springfield, Mass. (17). H F I
Bingham, Mrs. Martha A., Hotel Brunswick, Kansas City, Mo. (32).
Birdsall, Miss Louise W., 105 E. 37th St., New York, N. Y. (37). F E
Birge, Charles P., Keokuk, Iowa (29). E
Bishop, Heber R., Mills Building, New York, N. Y. (36).
Bishop, Irving P., Chatham, Columbia Co., N. Y. (35). E
Bixby, Wm. H., Wilmington, N. C. (34). D
Blacklock, Charles H., Rugby, Tenn. (35).
Blackwell, Mrs. A. B., Elizabeth, N. J. (30). F C B
Blaisdell, F. E., Coronado, San Diego Co., Cal. (29). F
Blake, Francis C., Mansfield Valley P. O., Allegheny Co., Pa. (29). C B D
Blake, L. I., Hyde Park, Mass. (36).
Blakslee, Prof. T. M., Des Moines, Iowa (31). A
Blatchford, Eliphalet W., 375 La Salle Ave., Chicago, Ill. (17). F
Bleile, Albert M., M.D., 342 S. Fourth St., Columbus, Ohio. (37) F
Blish, W. G., Niles, Mich. (33). B D
Blount, Henry F., Evansville, Vanderburg Co., Ind. (32). I B
Blount, Mrs. Lucia E., 518 Unity Square, Kalamazoo, Mich. (34). H I
Blue, Archibald, Ass't Minister of Agric., Toronto, Can. (35). I
Bohannan, R. W., University of Virginia, Va. (36).
Bolton, Prof. John, 49 Huntington St., Cleveland, Ohio. (37).
Booraem, J. V. V., 204 Lincoln Place, Brooklyn, N. Y. (36).
Booth, Miss Mary A., Longmeadow, Mass. (34). F I
Booth, Samuel C., Longmeadow, Mass. (34). E I

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Bothwell, Geo. W., M.A., Oakland, Cal. (36).
Bourland, Addison M., M.D., Van Buren, Ark. (29). C E F
Bourne, Robert W., Box 217, Providence, R. I. (34). D
Bowers, Miss Virginia K., 61 Taylor St., Newport, Ky. (27). F H B C
Bowman, Chas. G., Lt. U. S. N., care Navy Dept., Washington, D.C. (33)
Bowser, Mrs. Anna C., 828 Third St., Louisville, Ky. (33). H
Boyer, Jerome L., Sup't Chestnut Hill Iron Ore Co., Reading, Pa. (35). D
Brackett, Richard N., Chemist of the Geological Survey of Arkansas, Little Rock, Ark. (37). C E
Bradford, Edward H., M.D., 150 Boylston St., Boston, Mass. (29).
Bradford, Royal B., Lt. Comd'r, U. S. N., care of Navy Department, Washington, D. C. (31). B D
Braid, Andrew, U. S. Coast and Geodetic Survey Office, Washington, D. C. (33). C B A
Braid, James W., Nashville, Tenn. (33).
Bray, Prof. C. D., College Hill, Mass. (29). D B
Brayton, Miss Sarah H., M.D., Evanston, Ill. (33).
Breckinridge, S. M., P. O. Box 346, St. Louis, Mo. (27).
Breidenbaugh, Prof. E. S., Pennsylvania College, Gettysburg, Pa. (33). C
Brice, Judge Albert G., 122 Gravier St., New Orleans, La. (32). H
Brill, Prof. Charles C., Northfield, Vt. (36). F
Bringhurst, Prof. W. L., Agric. and Mechan. College of Texas, College Station, Brazos Co., Texas (32).
Bristol, Wm. H., Stevens Institute, Hoboken, N. Y. (36). A B D
Britton, Mrs. N. L., Columbia College, New York, N. Y. (31). F
Bromfield, Rev. Edw. T., Glenbrook, Fairfield Co., Conn. (33). F H
Brooke, Dr. Emma W., 15th and Chestnut Sts., Phila., Pa. (33). C E
Broomall, Hon. John M., Media, Delaware Co., Pa. (23). A
Brown, Albert P., Ph.D., 501 Federal St., Camden, N. J. (33). F C
Brown, Miss Anna M., 528 West 7th St., Cincinnati, Ohio (31). F
Brown, Prof. C. J., Clark Univ., Atlanta, Ga. (31). C B
Brown, Fred. G., Fort Ann, Washington Co., N. Y. (31). C E
Brown, Rev. Henry M., East Aurora, Erie Co., N. Y. (35). F C
Brown, Jonathan, 390 Broadway, Somerville, Mass. (29).
Brown, Paul Taylor, 2206 Green St., Philadelphia, Pa. (33). E
Brownell, Silas B., 71 Wall St., New York, N. Y. (36).
Brownell, Prof. Walter A., 125 Univ. Ave., Syracuse, N. Y. (30). E B C
Buck, Henry C., West Somerville, Mass. (29). B
Buckingham, Chas. L., 195 Broadway, New York, N. Y. (28).
Buffum, Miss Fannie A., Linden, Mass. (29). E C
Bulloch, Walter H., 99 W. Monroe St., Chicago, Ill. (30). F
Burke, William, U. S. Patent Office, Washington, D. C. (28).
Burnett, Chas. H., M.D., 127 So. 18th St., Philadelphia, Pa. (35). F B
Burns, Prof. James A., Box 456, Atlanta, Ga. (32). C E I
Burr, Mrs. Laura E., Commercial Hotel, Lansing, Mich. (34). B
Burwell, Arthur W., 1117 Lincoln Ave., Cleveland, Ohio (37).
Bush, Rev. Stephen, D.D., Waterford, N. Y. (19). E H
Byrd, Mary E., Observ. of Smith College, Northampton, Mass. (34). A

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Cabot, John W., Bellaire Nail Works, Bellaire, Belmont Co., Ohio (35). D
Calder, Edwin E., 15 Board of Trade Building, Providence, R. I. (29). C
Caldwell, Wm. H., State College, Centre Co., Pa. (37). I F
Calkins, Dr. Marshall, Springfield, Mass. (29).
Calvin, Prof. Samuel, State Univ. of Iowa, Iowa City, Iowa (37) B E
Campbell, Rev. Prof. John, Presbyterian College, Montreal, Can. (31). H
Campbell, Jos. Addison, Pulaski and Logan Sts., Germantown, Pa. (33).
Campbell, Wm. A., M.D., Ann Arbor, Mich. (34). F B
Capen, Miss Bessie T., Northampton, Mass. (23). C
Cardeza, John M., M.D., Claymont, Del. (33). E
Carman, Lewis, Bangall, N. Y. (29). E H
Caron, C. K., Louisville, Ky. (30). E C
Carpenter, Geo. O., jr., care of St. Louis Lead and Oil Co., St. Louis, Mo. (29).
Carpenter, Louis G., Agricultural College, Fort Collins, Col. (32). A B
Carroll, Alfred L., M.D., New Brighton, Staten Island, N. Y. (36). F
Carrington, Col. Henry B., U. S. A., 22 Bromfield St., Boston, Mass. (20).
Carter, Calvin, C.E., Brookville, Ind. (37) D
Carter, James C., 277 Lexington Ave., New York, N. Y. (36).
Carter, John E., Knox and Coulter Sts., Germantown, Pa. (33). B H
Cary, Albert A., 234 W. 29th St., New York, N. Y. (36). D
Catlin, Charles A., 12 Cooke St., Providence, R. I. (33). C
Causey, Francis F., Hampton, Va. (36) I
Chadbourn, Erlon R., Lewiston, Me. (29).
Chahoon, Mrs. Mary D., 134 S. Fourth St., Philadelphia, Pa. (33).
Chaffee, Prof. Arthur B., Franklin, Johnson Co., Ind. (37)
Champlin, John D., Jr., 745 Broadway, New York, N. Y. (36).
Chandler, Prof. John R., National Institute, Guatemala, Central America (36) F H
Chaplin, Prof. Winfield S., Harvard Univ., Cambridge, Mass. (37). D A
Charbonnier, Prof. L. H., University of Georgia, Athens, Ga. (26). A B D
Chase, Rev. E. B., Kent, Ohio (37).
Chase, Mrs. Mariné J., 1622 Locust St., Philadelphia, Pa. (31). E F
Chase, R. Stuart, 53 Summer St., Haverhill, Mass. (18). F
Chatfield, A. F., Albany, N. Y. (29).
Chester, Commander Colby M., U. S. N., care Navy Dept. Washington, D. C. (28). E
Childe, John Healey, 12 Brimmer St., Boston, Mass. (31).
Christie, James, Pencoyd, Pa. (33). D
Christy, Prof. Samuel B., Box 41, Berkeley, Cal. (35). D
Chrystie, Wm. F., Hastings-on-Hudson, New York, N. Y. (36).
Church, W. C., 240 Broadway, New York, N. Y. (36).
Chute, Horatio N., Ann Arbor, Mich. (34). B C A
Claghorn, Clarence R., M.E., Bernice, Sullivan Co., Pa. (37). E
Clapp, Geo. H., 98 Fourth Ave., Pittsburgh, Pa. (33). H C
Clark, Alex S., Westfield, N. J. (33).
Clark, John S., 7 Park St., Boston, Mass. (31). I B C

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Clark, Simeon T., M.D., 103 Genesee St., Lockport, Niagara Co., N. Y. (25). F
Clark, Wm. Brewster, M.D., 50 E. 31st St., New York, N. Y. (33). F C
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Wilkinson, J. Henderson, 820 E. Capitol St., Washington, D. C. (35). E
Wilkinson, Mrs. L. V., Seventy Six P. O., Perry Co., Mo. (30).
Willet, Joseph Edgerton, Macon, Ga. (36). E
Willetts, Joseph C., Skaneateles, N. Y. (29). E F H
Williams, C. T., 871 Case Ave., Cleveland, Ohio (37).
Williams, Prof. Edward H., jr., Box 463, Bethlehem, Pa. (25). E D
Williams, Francis H., M.D., Hotel Victoria, Boston, Mass. (29).
Williams, H. Smith, M.D., Independence, Iowa (34). F
Williams, J. Francis, Salem, N. Y. (31). C E
Willis, Bailey, U. S. Geol. Survey, Washington, D. C. (36).
Willson, Robert W., Cambridge, Mass. (30). B A
Wilmot, Thos. J., Commercial Cable Co., Waterville, County Kerry, Ireland (27). B
Wilson, C. H., Belize, British Honduras (30). E C D
Wilson, Chas. M., M.D., 1517 Walnut St., Philadelphia, Pa. (33). F H
Wilson, Prof. Edmund B., Bryn Mawr, Pa. (36).
Wilson, James M., Riverton, Ill. (33).
Wilson, Dr. Jas. C., Cor. 17th and Samson Sts., Philadelphia, Pa. (33). F
Wilson, Mrs. M. V. C., Mobile, Ala. (37).
Winchell, Horace V., 10 State St., Minneapolis, Minn. (34). E C
Winchell, Martin R., 120 Nassau St., New York, N. Y. (36). I
Wingate, Miss Hannah S., 12 W. 125th St., New York, N. Y. (31). E I
Winslow, Arthur, Geol. Survey of Arkansas, Little Rock, Ark. (37). E
Winterburn, Geo. Wm., M.D., 29 W. 26th St., New York, N. Y. (36). F H
Winterhalter, A. G., Lt. U. S. N., U. S. Naval Observ., Washington, D. C. (37). A
Wisser, John P., 1st Lt. 1st Art'y, U. S. A., West Point, N. Y. (33). C
Withers, W. A., A.M., Agricultural Experiment Station, Raleigh, N. C. (33). C
Witthaus, Dr. R. A., 410 E. 26th St., New York, N. Y. (35).

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Wolcott, Mrs. Henrietta L. T., Dedham, Mass. (29).
Wolf, Theo. R., Ph.D., Newark, Delaware (36).
Wolff, Dr. J. E., Cambridge, Mass. (36).
Wood, Harry A., M.D., State Insane Asylum, Buffalo, N. Y. (35).
Wood, Joseph S., Mount Vernon, Westchester Co., N. Y. (36).
Wood, Dr. Robert W., Jamaica Plain, Mass. (29).
Wood, Walter, 400 Chestnut St., Philadelphia, Pa. (33). F I
Wood, Dr. William B., 17 E. 38th St., New York, N. Y. (36).
Woodford, Prof. A. B., Indiana Univ., Bloomington, Ind. (36). I
Worthington, George, Editor Electrical Review, 13 Park Row, New York, N. Y. (36). B D
Wright, Rufus, 333–339 Lake St., Chicago, Ill. (37). B
Wright, Prof. Thos. W., Union College, Schenectady, N. Y. (36).
Würtele, Miss Minnie, Acton Vale, P. Q., Can. (32). H
Wyman, Walter Channing, 158 Dearborn St., Chicago, Ill. (34). H

Youmans, Mrs. Celia G., Mount Vernon, N. Y. (36).
Youmans, Wm. Jay, M.D., Popular Science Monthly, 1–5 Bond St., New York, N. Y. (28). F C
Young, Prof. A. Harvey, Hanover College, Hanover, Ind. (30). F C
Young, Albert B., 29 Park St., Buffalo, N. Y. (35).

Zalinski, E. L., 1st Lt., 5th Art'y, U. S. A., Fort Hamilton, N. Y. (36).
Zimmerman, William, 164 Dearborn St., Chicago, Ill. (30). F D B

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HONORARY FELLOWS.[1]

ROGERS, WILLIAM B., Boston, Mass. (1). 1881. (Died in 1882.)
CHEVREUL, MICHEL EUGÈNE, Paris, France (35). 1886. (Died in 1889.)
GENTH, DR. F. A., 3937 Locust St., Philadelphia, Pa. (24). 1875. 1888. C E

FELLOWS.[2]

Aaron, Eugene M., Box 916, Philadelphia, Pa. (33). 1886. F
Abbe, Professor Cleveland, Army Signal Office, Washington, D. C. (16). 1874. B A
Abbott, Dr. Chas. C., Trenton, N. J. (29). 1883. F H
Adams, Frank Dawson, 141 Rideau St., Ottawa, Can. (29). 1885.
Alden, Prof. Geo. I., Worcester, Mass. (33). 1885. D
Alexander, John S., Texas Nat'l Bank, San Antonio, Texas (20). 1874. B C D
Allen, Dr. Harrison, 117 S. 20th St., Philadelphia, Pa. (29). 1882. F
Allen, Joel A., American Museum of Natural History, Central Park, New York (18). 1875. F
Allen, Dr. T. F., 10 E. 36th St., New York, N. Y. (35). 1887. F
Alvord, Major Henry E., Agricultural College, Md. (29). 1882. I
Ammen, Daniel, Rear Admiral U. S. Navy, Beltsville, Md. (26). 1881. E
Anderson, Dr. Joseph, Waterbury, Conn. (29). 1883. H
Anthony, Prof. Wm. A., Manchester, Conn. (28). 1880. B
Arthur, J. C., La Fayette, Ind. (21). 1883. F
Ashburner, Charles A., Penn Building, Pittsburgh, Pa. (31). 1883. E
Atkinson, Edward, 31 Milk St., Boston, Mass. (29). 1881. I D
Atwater, Prof. W. O., Wesleyan Univ., Middletown, Conn. (29). 1882. C
Auchincloss, Wm. S., 209 Church St., Philadelphia, Pa. (29). 1886. D A
Ayres, Prof. Brown, Tulane University, New Orleans, La. (31). 1885. B

Babbitt, Miss Franc E., Lock Box 1284, Coldwater, Mich. (32). 1887. H I
Babcock, S. Moulton, Madison, Wis. (33). 1885. C
Bailey, Prof. Liberty H., Agricultural College, Mich. (34). 1887. F
Bailey, Prof. W. W., Brown University, Providence, R. I. (18). 1874. F
Baker, Frank, M.D., 1315 Corcoran St., Washington, D. C. (31). 1886. F H

[1] See ARTICLE VI of the Constitution. [2] See ARTICLE IV of the Constitution.

*** The number in parenthesis indicates the meeting at which the member joined the Association; the date following is the year when made a Fellow; the black letters at end of line are those of the sections to which the fellow belongs.

When the name is given in small capitals, it designates that the Fellow is also a Life Member, and is entitled to the Annual Volume of Proceedings.

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Baker, Marcus, U. S. Geological Survey, Washington, D. C. (30). 1882. **A**

Barker, Prof. G. F., Univ. of Penn., Philadelphia, Pa. (13). 1875. **B C**

Barnard, Edward E., Lick Observ., San José, Cal. (26). 1883. **A**

Barnard, F. A. P., President Columbia College, New York, N. Y. (7). 1874. **B D I A F**

Barnes, Prof. Chas. R., Madison, Wis. (33). 1885 **F**

Bartlett, Prof. Edwin J., Dartmouth College, Hanover, N. H. (28). 1883. **C**

Bartlett, John R., Commander U. S. N., Navy Dep't, Washington, D. C. (30). 1882. **E B**

Barus, Carl, Ph.D., U. S. Geol. Survey, Washington, D. C. (33). 1887. **B**

Bassett, Homer F., Waterbury, Conn. (23). 1874. **F**

Batchelder, John M., 3 Divinity Avenue, Cambridge, Mass. (8). 1875. **B D I**

Bates, Henry Hobart, U. S. Patent Office, Washington, D. C. (33). 1887. **B A C D**

Bausch, Edward, Rochester, N. Y. (26). 1883. **A B C F**

Beal, Prof. Wm. James, Agricultural College, Ingham Co., Mich. (24). 1880. **F**

Beardsley, Prof. Arthur, Swarthmore College, Swarthmore, Del. Co., Pa. (33). 1885. **D**

Beauchamp, Rev. Wm. M., Baldwinsville, N. Y. (34). 1886. **H**

Bebb, M. S., 926 Grant Ave., Rockford, Ill. (34). 1886. **F**

Bell, Dr. Alex. Graham, Scott Circle, 1500 Rhode Island Ave., Washington, D. C. (26). 1879. **B H I**

Bell, Alex. Melville, 1525 35th St., Washington, D. C. (31). 1885. **H**

Bell, Samuel N., Manchester, N. H. (7). 1874.

Beman, Wooster W., 19 So. 5th St., Ann Arbor, Mich. (34). 1886. **A**

Benjamin, Marcus, 15 W. 121st St., New York, N. Y. (27). 1887. **C**

Benjamin, Rev. Raphael, M.A., 1334 Lexington Ave., New York, N. Y. (34). 1887. **F A B D E H I**

Bessey, Prof. Charles E., Univ. of Nebraska, Lincoln, Neb. (21). 1880. **F**

Bethune, Rev. C. J. S., Trinity College School, Pt. Hope, Ont., Can. (18). 1875. **F**

Beyer, Dr. Henry G., U. S. N., U. S. National Museum, Washington, D. C. (31). 1884. **F**

Bickmore, Prof. Albert S., American Museum of Natural History, 8th Ave. and 77th St., Central Park, New York, N. Y. (17). 1880. **H**

Bigelow, Prof. Frank H., Racine, Wis. (36) 1888. A

Billings, John S., Surgeon U. S. A., Surg. General's Office, Washington, D. C. (32). 1883. **F H**

Blackham, George E., M.D., Dunkirk, N. Y. (25). 1883. **F**

Blake, Clarence J., M.D., 226 Marlborough St., Boston, Mass. (24). 1877. **B F**

Blake, Prof. Eli W., Brown Univ., Providence, R. I. (15). 1874. **B**

Blake, Francis, Auburndale, Mass. (23). 1874. **B A**

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Boardman, Mrs. William D., 38 Kenilworth St., Roxbury, Mass. (28). 1885. **E H**

Boas, Dr. Franz, 196 Third Ave., New York, N. Y. (36) 1888. **H**

Boerner, Chas. G., Vevay, Switzerland Co., Ind. (29). 1886. **A B E**

Bolton, Dr. H. Carrington, University Club, New York, N. Y. (17). 1875. **C**

Bond, Geo. M., care of The Pratt & Whitney Co., Hartford, Conn. (33). 1885. **D**

Borden, Spencer, Fall River, Mass. (29). 1882. **B C I**

Boss, Prof. Lewis, Director Dudley Observ., Albany, N. Y. (26). 1878.

Bourke, John G., Capt. 3d Cavalry, U. S. A., War Dept., Washington, D. C. (33). 1885. **H**

Bouvé, Thos. T., Boston Soc. Nat. Hist., Boston, Mass. (1). 1875. **E**

Bowditch, Prof. H. P., Jamaica Plain, Mass. (28). 1880. **F B H**

Bowditch, Henry I., M.D., 113 Boylston St., Boston, Mass. (2). 1875. **F H**

Bowser, Prof. E. A., Rutgers College, New Brunswick, N. J. (28). 1881.

Brace, DeWitt B., Lincoln, Neb. (35). 1887. **B**

Brackett, Prof. C. F., College of New Jersey, Princeton, N. J. (19). 1875. **B**

Brackett, Solomon H., St. Johnsbury, Vt. (29). 1884. **B A**

Branner, John C., Director of the Geological Survey of Arkansas, Little Rock, Ark. (34). 1886. **E F**

Bransford, John Francis, Surgeon U. S. N., Smithsonian Institution, Washington, D. C. (36) 1888. **H I**

Brashear, Jno. A., Allegheny, Pa. (33). 1885. **A B D**

Brewer, Prof. Wm. H., New Haven, Conn. (20). 1875. **E F I**

Brewster, William, 61 Sparks St., Cambridge, Mass. (29). 1884. **F**

Brinton, D. G., M.D., Media, Pa. (33). 1885. **H**

Britton, N. L., Columbia College, New York, N. Y. (29). 1882. **F E**

Broadhead, Garland Carr, Pleasant Hill, Cass Co., Mo. (27). 1879. **E**

Brooks, Wm. R., Geneva, N. Y. (35). 1886. **A**

Bross, Hon. Wm., Tribune Office, Chicago, Ill. (7). 1874. **E H**

Brown, Robert, care of Yale College Observatory, New Haven, Conn. (11). 1874.

Brown, Mrs. Robert, New Haven, Conn. (17). 1874.

Brühl, Gustav, cor. John and Hopkins Sts., Cincinnati, Ohio (28). 1886. **H**

Brush, Charles F., Brush Electric Light Co., Cleveland, Ohio (35). 1886. **B**

Brush, Prof. George J., Yale College, New Haven, Conn. (4). 1874. **C E**

Buckhout, W. A., State College, Centre Co., Pa. (20). 1881. **F**

Burnham, S. W., Lick Observ., San José, Cal. (25). 1877. **A**

Burr, Prof. William H., Phoenixville, Chester Co., Pa. (31). 1883.

Burrill, Prof. T. J., Univ. of Illinois, Champaign, Ill. (29). 1882. **F**

Butler, A. W., Brookville, Franklin Co., Ind. (30). 1885. **F H**

Caldwell, Prof. Geo. C., Cornell University, Ithaca, N. Y. (23). 1875. **C**

Campbell, Douglas H., 91 Alfred St., Detroit, Mich. (34) 1888. **F**

Campbell, Edw. D., Box 402, Sharon, Mercer Co., Pa. (34). 1887. **C**

Canby, William M., 1101 Delaware Avenue, Wilmington, Del. (17). 1878. **F**

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Carhart, Prof. Henry S., University of Michigan, Ann Arbor, Mich. (29). 1881. **B**

Carmichael, Prof. Henry, 7 Broad St., Boston, Mass. (21). 1875. **C**

Carpenter, Capt. W. L., U. S. A., Dunkirk, N. Y. (24). 1877. **F E**

Carpmael, Charles, Director of Magnetic Observatory, Toronto, Can. (31). 1883. **B**

Carr, Lucien, Peabody Museum Archæology and Ethnology, Cambridge, Mass. (25). 1877. **H**

Case, Col. Theo. S., Kansas City, Mo. (27). 1883. **H B**

Chamberlin, T. C., Madison, Wis. (21). 1877. **E B F H**

Chandler, Prof. C. F., School of Mines, Columbia Coll., East 49th St. cor. 4th Ave., New York, N. Y. (19). 1875. **C**

Chandler, Prof. Charles Henry, Ripon, Wis. (28). 1883. **A B**

Chandler, Seth C., jr., 16 Cragie St., Cambridge, Mass. (29). 1882. **A**

Chandler, Prof. W. H., South Bethlehem, Pa. (19). 1874. **C**

Chanute, O., Kansas City, Mo. (17). 1877. **D I**

Chapin, Dr. J. H., Meriden, Conn. (33). 1886. **E H**

Chester, Prof. Albert H., Hamilton College, Clinton, N. Y. (29). 1882. **C F**

Chester, Prof. Fred'k D., Del. State Coll., Newark, Del. (33). 1887. **E**

Chickering, Prof. J. W., jr., Deaf Mute College, Washington, D. C. (22). 1877. **F I**

Chittenden, Russell H., Ph.D., New Haven, Conn. (29). 1882. **C F**

Clapp, Miss Cornelia M., Mt. Holyoke Seminary, South Hadley, Mass. (31). 1883. **F**

Clark, Alvan G., Cambridgeport, Mass. (28). 1880. **A B**

Clark, Prof. John E., Mathematics, Yale College, New Haven, Conn. (17). 1875. **A**

Clarke, Prof. F. W., U. S. Geological Survey, Washington, D. C. (18). 1874. **C**

Claypole, Prof. Edw. W., Buchtel Coll., Akron, Ohio (30). 1882. **E F**

Clayton, H. Helm, Readville, Mass. (34). 1887. **B**

Cloud, John W., Buffalo, N. Y. (28). 1886. **A B D**

Coffin, Prof. John H. C., U. S. Navy, 1901 I St., Washington, D. C. (1). 1874. **A**

Coffin, Prof. Selden J., Lafayette College, Easton, Pa. (22). 1874. **A I**

Collett, Prof. John, Indianapolis, Ind. (17). 1874. **E**

Collingwood, Francis, Elizabeth, N. J. (36). 1888. **D**

Colvin, Verplanck, Supt. N. Y. State Adirondack Survey, Albany, N. Y. (28). 1880. **E**

Comstock, Prof. Geo. C., Washburn Observ., Univ. of Wisconsin, Madison, Wis. (34). 1887. **A**

Comstock, J. Henry, Cornell Univ., Ithaca, N. Y. (28). 1882. **F**

Comstock, Prof. Theo. B., Prof. of Mining Engineering, Univ. of Illinois, Champaign, Ill. (24). 1877. **D E B**

Cook, Prof. A. J., Agricultural College, Mich. (24). 1880. **F**

Cook, Prof. George H., New Brunswick, N. J. (4). 1875. **E**

Cooley, Prof. Le Roy C., Vassar College, Poughkeepsie, N. Y. (19). 1880. **B C**

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Cooley, Prof. Mortimer E., Univ. of Michigan, Ann Arbor, Mich. (33). 1885. **D**

Cope, Prof. Edward D., 2100 Pine St., Philadelphia, Pa. (17). 1875. **F E**

Corthell, Elmer L., 205 La Salle St., Chicago, Ill. (34). 1886. **D**

Coulter, Prof. John M., Wabash Coll., Crawfordsville, Ind. (32). 1884. **F**

Cox, Prof. Edward T., New Harmony, Ind. (19). 1874. **E**

Cox, Hon. Jacob D., Gilman Ave., Mt. Auburn, Cincinnati, Ohio (30). 1881. **F**

Coxe, Eckley B., Drifton, Luzerne Co., Pa. (23). 1879. **D E**

Crampton, Chas. A., Dept. of Agric., Washington, D. C. (36). 1887. **C**

Crandall, Prof. A. R., Lexington, Ky. (29). 1883. **E F**

Crocker, Susan E., M.D., Lawrence, Mass. (21). 1874. **E F**

Crosby, Prof. Wm. O., Boston Society of Natural History, Boston, Mass. (29). 1881. **E**

Cross, Prof. Chas. R., Mass. Institute Technology, Boston, Mass. (29). 1880. **B**

Cummings, Rev. Joseph, D.D., President Northwestern University, Evanston, Ill. (18). 1874. **I H**

Cushing, Henry Platt, Box 482, Mankato, Minn. (33). 1888. **E**

Cutting, Hiram A., M.D., State Geologist, Lunenburgh, Vt. (17). 1874. **E F**

Dabney, Chas. W., jr., Ph.D., Agricultural Experiment Station, Raleigh, N. C. (30). 1882. **C B E**

Dall, Mrs. Caroline H., 1630 O St., Washington, D. C. (18). 1874. **F H**

Dall, William H., Smithsonian Institution, Washington, D. C. (18). 1874. **H F**

Dana, Edward Salisbury, New Haven, Conn. (23). 1875. **B E**

Dana, Prof. James D., New Haven, Conn. (1). 1875. **E**

Danforth, Edward, Department of Public Instruction, Elmira, N. Y. (11). 1874. **E I H A B**

Davenport, B. F., M.D., 161 Tremont St., Boston, Mass. (29). 1883. **C**

Davidson, Prof. Geo., U. S. Coast and Geodetic Survey, San Francisco, Cal. (29). 1881. **A B D**

Davis, Wm. Morris, Cambridge, Mass. (33). 1885. **E B**

Dawson, Sir William, Principal McGill College, Montreal, Can. (10). 1875. **E**

Day, David F., Buffalo, N. Y. (35). 1887. **F**

Day, F. H., M.D., Wauwatosa, Wis. (20). 1874. **E H F**

Dean, George W., P. O. Box 92, Fall River, Mass. (15). 1874. **A**

Denton, Prof. James E., Stevens Institute, Hoboken, N. J. (36) 1888. **D B A**

Dewey, Fred P., Ph.B., Smithsonian Institution, Washington, D. C. (30). 1886. **C E**

Diller, J. Silas, U. S. Geol. Survey, Washington, D. C. (29). 1884. **E**

Dimmock, George, Cambridge, Mass. (22). 1874. **F**

Dinwiddie, Robert, 117 W. 43d St., New York, N. Y. (1). 1874. **F**

Dodge, Charles R., Washington, D. C. (22). 1874.

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Dodge, Prof. James A., University of Minnesota, Minneapolis, Minn. (29). 1884. **C E**

Dodge, J. Richards, Washington, D. C. (31). 1884. **I H**

Dolbear, A. Emerson, College Hill, Mass. (20). 1880. **B**

Doolittle, Prof. C. L., South Bethlehem, Pa. (25). 1885. **A**

Dorsey, Rev. J. Owen, Box 591, Washington, D. C. (31). 1883. **H**

Douglass, Andrew E., P. O. Box 605, New York, N. Y. (31). 1885. **H**

Dow, Capt. John M., 69 Seventh Ave., New York, N. Y. (31). 1884. **F H**

Draper, Dan'l, Ph. D., Director N. Y. Meteorological Observatory, Central Park, 64th St., Fifth Avenue, New York, N. Y. (29). 1881. **B D F A**

Drown, Prof. Thos. M., Mass. Institute Technology, Boston, Mass. (29). 1881. **C**

Du Bois, Prof. Aug. J., New Haven, Conn. (30). 1882. **A B D**

Du Bois, Patterson, Ass't Editor S.S.T., 1031 Walnut St., Philadelphia, Pa. (33). 1887. **H C I**

Dudley, Charles B., Altoona, Pa. (23). 1882. **C B D**

Dudley, P. H., 66½ Pine St., New York, N. Y. (29). 1884.

Dudley, Wm. L., Prof. of Chemistry, Vanderbilt Univ., Nashville, Tenn. (28). 1881. **C**

Dudley, Prof. Wm. R., Ithaca, N. Y. (29). 1883. **F**

Dunnington, Prof. F. P., University of Virginia, Va. (26). 1880. **C**

Dutton, Capt. C. E., U. S. Geol. Surv., Washington, D. C. (23). 1875.

Dwight, Prof. William B., Vassar College, Poughkeepsie, N. Y. (30). 1882. **E F**

Eastman, Prof. J. R., U. S. Naval Observatory, Washington, D. C. (26). 1879. **A**

Eaton, Prof. D. G., 55 Pineapple St., Brooklyn, N. Y. (19). 1874. **B E**

Eaton, Prof. James R., Liberty, Mo. (29). 1885. **C B E**

Eddy, Prof. H. T., Univ. of Cincinnati, Cincinnati, O. (24). 1875. **A B D**

Edison, Thos. A., Menlo Park, N. J. (27). 1878. **B**

Edmands, J. Rayner, Observatory, Cambridge, Mass. (29). 1880.

Egleston, Prof. Thomas, 35 W. Washington Square, New York, N. Y. (27). 1879. **C D E**

Eimbeck, William, U. S. C. and G. S., Washington, D. C. (17). 1874. **A B D**

Elkin, William L., Yale Coll. Observ., New Haven, Conn. (33). 1885. **A**

Elliott, Arthur H., 591 Broadway, care Anthony's Bulletin, New York, N. Y. (23). 1880. **C**

Ely, Theo. N., Sup't Motive Power, Penn. R. R., Altoona, Pa. (29). 1886.

Emerson, Prof. Benjamin K., Amherst, Mass. (19). 1877. **E F**

Emerson, Prof. C. F., Dartmouth Coll., Hanover, N. H. (22). 1874. **B A**

Emerton, James H., 11 St. James Ave., Boston, Mass. (18). 1875. **F**

Emery, Albert H., Stamford, Conn. (29). 1884. **D B**

Emery, Charles E., 22 Cortlandt St., New York, N. Y. (34). 1886. **D B A**

Emmons, S. F., U. S. Geol. Survey, Washington, D. C. (26). 1879. **E**

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Engelmann, George J., M.D., 3003 Locust St., St. Louis, Mo. (25). 1875. **F H**

Evans, Asher B., 500 Pine St., Lockport, N. Y. (19). 1874. **A**

Fairbanks, Henry, Ph.D., St. Johnsbury, Vt. (14). 1874. **B D A**

Fairchild, Prof. H. L., University of Rochester, Rochester, N. Y. (28). 1883. **E F**

Fall, Prof. Delos, Albion College, Albion, Mich. (34). 1887. **C**

Fanning, John T., Union Depot Building, Minneapolis, Minn. (29). 1885. **D**

Farlow, Dr. W. G., 29 Holyoke House, Cambridge, Mass. (20). 1875. **F**

Farmer, Moses G., Eliot, Me. (9). 1875.

Farquhar, Henry, Coast Survey Office, Washington, D. C. (33). 1886. **A I F B**

Fernald, Prof. Charles H., Amherst, Mass. (22). 1881. **F E**

Fernald, Prof. M. C., State Agric. College, Orono, Me. (22). 1883. **B A**

Fernow, Bernhard E., Chief of Forestry Division, Dep't of Agriculture, Washington, D. C. (31). 1887. **F I**

Ferrel, Wm., 1641 Broadway, Kansas City, Mo. (11). 1875. **A B**

Ficklin, Prof. Joseph, Univ. of Missouri, Columbia, Mo. (20). 1878. **A B**

Fine, Prof. Henry B., College of New Jersey, Princeton, N. J. (35). 1887. **A**

Firmstone, F., Easton, Pa. (33). 1887. **D**

Fitch, Edward H., Jefferson, Ashtabula Co., Ohio (11). 1874. **I E**

Fletcher, Miss Alice C., care Peabody Museum, Cambridge, Mass. (29). 1883. **H**

Fletcher, James, Dep't of Agriculture, Ottawa, Can. (31) 1883. **F**

Fletcher, Dr. Robert, Surgeon General's Office, U. S. A., Washington, D. C. (29). 1881. **F H**

Flint, Albert S., U. S. Naval Observ., Washington, D. C. (30). 1887. **A**

Flint, James M., Surgeon U. S. N., Smithsonian Institution, Washington, D. C. (28). 1882. **F**

Foote, Dr. A. E., 1223 Belmont Ave., Philadelphia, Pa. (21). 1874. **E C**

Forbes, Prof. S. A., Univ. of Illinois, Champaign, Ill. (27). 1879. **F**

Fox, Prof. Joseph G., Lafayette College, Easton, Pa. (31). 1886. **A B D**

Foye, Prof. J. C., Lawrence Univ., Appleton, Wis. (29). 1884. **C B**

Frazer, Dr. Persifor, 917 Clinton St., Philadelphia, Pa. (24). 1879. **E C**

Frazier, Prof. B. W., The Lehigh Univ., Bethlehem, Pa. (24). 1882. **E C**

Frear, Wm., State College, Centre Co., Pa. (33). 1886. **C**

French, Prof. Thomas, jr., Ridgeway Ave., Avondale, Cincinnati, Ohio (30). 1883. **B**

Frisby, Prof. Edgar, U. S. N. Observ., Washington, D. C. (28). 1880. **A**

Fuller, Andrew S., Ridgewood, Bergen Co., N. J. (24). 1882. **F**

Fulton, Prof. Robert B., University, Miss. (21). 1887. **B A**

Gage, Simon Henry, Ithaca, N. Y. (28). 1881. **F**

Gannett, Henry, U. S. Geological Survey, Washington, D. C. (33). 1884. **E I A**

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Gardiner, Rev. Frederic, D.D., Middletown, Conn. (23). 1874. C B
Gardiner, James T., 21 Elk St., Albany, N. Y. (25). 1879. E
Garland, Rev. Dr. L. C., Chancellor Vanderbilt University, Nashville, Tenn. (25). 1877 B
Garman, Samuel, Museum Comparative Zoology, Cambridge, Mass. (20). 1874. F E
Gatschet, Dr. Albert S., Box 333, Washington, D. C. (30). 1882. H
Gibbs, Prof. J. Willard, New Haven, Conn. (33). 1885. B
Gilbert, G. K., Box 591, Washington, D. C. (18). 1874. E
Gill, Prof. Theo., Smithsonian Institution, Washington, D. C. (17). 1874.
Gilliman, Henry, U. S. Consul, Jerusalem, Palestine, via England and Brindisi. (24). 1875. H F
Gilman, Daniel C., President Johns Hopkins University, Baltimore, Md. (10). 1875. E H
Goessman, Prof. C. A., Mass. Agric. Coll., Amherst, Mass. (18). 1875. C
Gold, Theodore S., West Cornwall, Conn. (4). 1887. B C
Goldschmidt, S. A., Ph.D., 55 Broadway, New York, N. Y. (24). 1880. C E B
Gooch, Frank A., Yale College, New Haven, Conn. (25). 1880. C
Goodale, Prof. G. L., Botanic Gardens, Cambridge, Mass. (18). 1875.
Goode, G. Brown, Curator Nat'l Museum, Washington, D. C. (22). 1874.
Goodfellow, Edward, Ass't U. S. Coast and Geodetic Survey, Washington, D. C. (24). 1879. A H
Gould, Dr. B. A., Cambridge, Mass. (2). 1875. A B
Grant, Mrs. Mary J., Brookfield, Conn. (23). 1874. A
Gratacap, L. P., Ph.B., 77th St. and 8th Ave., New York, N. Y. (27). 1884. C E F
Gray, Elisha, Sc.D., Highland Park, Ill. (32). 1883. B
Green, Arthur L., La Fayette, Ind. (33). 1888. C
Green, Traill, M.D., Easton, Pa. (1). 1874. C F
Grimes, J. Stanley, Evanston, Cook Co., Ill. (17). 1874. E H
Grinnell, George Bird, 40 Park Row, New York, N. Y. (25). 1885. F E
Gulley, Prof. Frank A., College Station, Texas. (30). 1883.

Hagen, Dr. Hermann A., Museum Comparative Zoology, Cambridge, Mass. (17). 1875. F
Hague, Arnold, U. S. Geol. Survey, Washington, D. C. (26). 1879.
Hale, Albert C., Ph.D., No. 356 Carlton Ave., Brooklyn, N. Y. (29). 1886. C B
Hale, Horatio, Clinton, Ontario, Can. (30). 1882. H
Hall, Prof. Asaph, U. S. Naval Observ., Washington, D. C. (25). 1877. A
Hall, Prof. C. W., 803 Univ. Ave. So., Minneapolis, Minn. (28). 1883. E
Hall, Prof. Edwin H., 5 Avon St., Cambridge, Mass. (29). 1881. B
Hall, Prof. James, Albany, N. Y. (1). 1875. E F
Hall, Prof. Lyman B., Haverford College, Pa. (31). 1884. C
Halsted, Byron D., New Jersey Agricultural Experiment Station, New Brunswick, N. J. (29). 1883. F

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Hamlin, Dr. A. C., Bangor, Me. (10). 1874. **C E H**
Hanaman, C. E., Troy, N. Y. (19). 1883. **F**
Hardy, Prof. A. S., Dartmouth College, Hanover, N. H. (28). 1883. **A**
Harger, Oscar, 14 University Place, New Haven, Conn. (25). 1879. **F E**
Harkness, Prof. William, U. S. N. Observatory, Washington, D. C. (26). 1878. **A B C D**
Harris, Uriah R., Lieutenant U. S. N., Navy Yard, Mare Island, Vallejo, Cal. (34). 1886. **A**
Harris, W. T., Lock Box 1, Concord, Mass. (27). 1887. **H I**
Hart, Edw., Ph.D., Easton, Pa. (33). 1885. **C**
Hasbrouck, Prof. I. E., 364 Carlton Ave., Brooklyn, N. Y. (23). 1874. **D A I**
Hastings, C. S., Sheffield Scientific School of Yale College, New Haven, Conn. (25). 1878. **B**
Haupt, Prof. Lewis M., University of Pennsylvania, Philadelphia, Pa. (32). 1885. **I D E**
Haynes, Henry W., 239 Beacon St., Boston, Mass. (28). 1884. **H**
Heilprin, Prof. Angelo, Acad. Nat. Sciences, Philadelphia, Pa. (33). 1885. **E F**
Hendricks, J. E., Des Moines, Iowa (29). 1885. **A**
Henshaw, Henry W., Bureau of Ethnology, Washington, D. C. (24). 1877. **H**
Hering, Rudolph, 31 Chambers St., Room 19, New York, N. Y. (33). 1885. **D E I**
Herrick, Clarence L., Granville, Ohio (31). 1884. **F E**
Hervey, Rev. A. B., Taunton, Mass. (22). 1879. **F**
Hicks, Prof. Lewis E., State University, Lincoln, Neb. (31). 1885. **E F**
Hilgard, Prof. E. W., University of California, Berkeley, Cal. (11). 1874. **C E B**
Hilgard, Prof. J. E., Washington, D. C. (4). 1874. **A**
Hill, Chas. S., care Dep't of State, Washington, D. C. (33). 1887. **A I**
Hill, Rev. Dr. Thomas, 738 Congress St., Portland, Me. (3). 1875. **A**
Himes, Prof. Charles F., Carlisle, Pa. (29). 1882. **B C**
Hitchcock, Prof. Charles H., Hanover, N. H. (11). 1874. **E**
Hitchcock, Romyn, Washington, D. C. (29). 1881. **C B**
Hobbs, A. C., Bridgeport, Conn. (28). 1886. **D**
Hodges, N. D. C., Editorial office of Science, 47 Lafayette St., New York, N. Y. (29). 1882. **B**
Hoffmann, Dr. Fred., 183 Broadway, New York, N. Y. (28). 1881. **C F**
Holden, Prof. E. S., Lick Observatory, San José, Cal. (23). 1875. **A**
Holman, Silas W., Massachusetts Institute of Technology, Boston, Mass. (31). 1883. **B**
Holmes, Prof. Jos. A., Chapel Hill, N. C. (33). 1887. **E F**
Holmes, Dr. Oliver Wendell, 296 Beacon St., Boston, Mass. (29). 1881. **H**
Holmes, Wm. H., Bureau of Ethnology, Smithsonian Institution, Washington, D. C. (30). 1883. **H**
Horsford, Prof. E. N., Cambridge, Mass. (1). 1876. **C E**

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Hosea, Lewis M., Johnston Building, Cincinnati, Ohio (30). 1883.
Hotchkiss, Major Jed., Staunton, Va. (31). 1883. **E H I**
Hough, Prof. G. W., Director Dearborn Observatory, Chicago, Ill. (15). 1874. **A**
Hovey. Rev. Horace C., 14 Park St., Bridgeport, Conn. (29). 1883. **E H**
Howe, Jas. Lewis, Louisville, Ky. (36). 1888. **C**
Hoy, Philo R., M.D., 902 Main St., Racine, Wis. (17). 1875. **F H**
Hulst, Rev. Geo. D., 15 Himrod St., Brooklyn, N. Y. (29). 1887. **F**
Hunt, George, Providence, R. I. (9). 1874.
Hunt, Dr. T. Sterry, Park Avenue Hotel, New York, N. Y. (1). 1874. **C E**
Hyatt, Prof. Alpheus, Natural History Society, Boston, Mass. (18). 1875. **E**
Hyde, Prof. E. W., Station D, Cincinnati, Ohio (25). 1881. **A**

Iddings, Joseph P., U. S. Geol. Survey, Washington, D. C. (31). 1884. **E**
Irving, Roland D., Wisconsin State Geol. Survey, Madison, Wis. (26). 1879. **E**

James, Edmund J., Ph.D., Univ. of Pa., Philadelphia, Pa. (33). 1887. **I**
James, Jos. F., M.S., Agricultural College, Prince George's Co., Md. (30). 1882. **F E**
Jastrow, Dr. Jos., Johns Hopkins Univ., Baltimore, Md. (35). 1887. **H F**
Jayne, Horace F., 1826 Chestnut St., Philadelphia, Pa. (29). 1884. **F H**
Jeffries, B. Joy, M.D., 15 Chestnut St., Boston, Mass. (29). 1881. **F H**
Jenkins, Edw. H., New Haven, Conn. (33). 1885. **C**
Jenks, Elisha T., Middleborough, Mass. (22). 1874. **D**
Jenks, Prof. J. W. P., Middleborough, Mass. (2). 1874. **B**
Jewell, Theo. F., Commander U. S. N., Torpedo Station, Newport, R. I. (25). 1882. **B**
Jillson, Dr. B. C., 842 River Ave., E.E., Pittsburgh, Pa. (14). 1881. **E H F**
Johnson, John B., Washington Univ., St. Louis, Mo. (33). 1886. **D**
Johnson, Lawrence C., 1330 F St., N. W., Washington, D. C. (33). 1887.
Johnson, Otis C., Ann Arbor, Mich. (34). 1886. **C**
Johnson, Prof. S. W., 54 Trumbull St., New Haven, Conn. (22). 1874. **C**
Johnson, Prof. W. W., Naval Academy, Annapolis, Md. (29). 1881. **A**
Joy, Prof. Charles A., care F. Hoffmann, Stockbridge, Mass. (8). 1879.
Julien, A. A., New York Acad. of Sciences, New York, N. Y. (24). 1875. **E C**

Kedzie, Prof. Robert C., Agricultural College, Mich. (29). 1881. **C**
Keiser, Edward H., Ph.D., Prof. of Chemistry, Bryn Mawr College, Bryn Mawr, Montgomery Co., Pa. (35). 1888. **C**
Kellicott, David S., Columbus, Ohio. (31). 1883. **F**
Kemp, James F., Cornell Univ., Ithaca, N. Y. (36). 1888. **E**
Kendall, Prof. E. Otis, 3826 Locust St., Philadelphia, Pa. (29). 1882. **A**
Kent, William, Passaic, N. J. (26). 1881. **D I**
Kershner, Prof. Jefferson E., Lancaster City, Pa. (29). 1883. **A B**

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Kimball, Arthur Lalanne, Johns Hopkins Univ., Baltimore, Md. (33). 1885. **B**

Kingsley, Prof. J. Sterling, Bloomington, Ind. (33). 1886. **F**

Kinnicutt, Dr. Leonard P., Polytechnic Inst., Worcester, Mass. (28). 1883. **C**

Kirkwood, Prof. Daniel, Bloomington, Ind. (7). 1874. **A**

Kunz, G. F., with Tiffany & Co., New York, N. Y. (29). 1883. **E H C**

Laflamme, Prof. J. C. K., Laval Univ., Quebec, Can. (29). 1887. **E B**

LaFlesche, Francis, Indian Bureau, Interior Dep't, Washington, D. C. (33). 1885. **H**

Lambert, Rev. Thomas R., D.D., Hotel Oxford, Huntington Ave., Boston, Mass. (18). 1874.

Landreth, Prof. Olin H., Vanderbilt Univ., Nashville, Tenn. (28). 1883. **D**

Langdon, Dr. F. W., 65 West 7th St., Cincinnati, Ohio (30). 1882. **F H**

Langley, Prof. J. W., Univ. of Mich., Ann Arbor, Mich. (23). 1875. **C B**

Langley, Prof. S. P., Secretary Smithsonian Institution, Washington, D. C. (18). 1874. **A B**

Lanza, Prof. Gaetano, Mass. Institute of Technology, Boston, Mass. (29). 1882. **D A B**

Larkin, Edgar L., Director Knox College Observatory, Galesburg, Ill. (28). 1883. **A**

Lattimore, Prof. S. A., University of Rochester, Rochester, N. Y. (15). 1874. **C**

Lawrence, George N., 45 E. 21st St., New York, N. Y. (7). 1877. **F**

Lazenby, Prof. Wm. R., Columbus, Ohio (30). 1882. **B I**

Leavenworth, Francis P., Haverford College P. O., Montgomery Co., Pa. (30). 1888. **A**

LeConte, Prof. Joseph, Univ. of Cal., Berkeley, Cal. (29). 1881. **E F**

Ledoux, Albert R., Ph.D., 10 Cedar St., New York, N. Y. (26). 1881. **C**

Leeds, Prof. Albert R., Stevens Institute, Hoboken, N. J. (23). 1874. **C F**

Lehman, G. W., Ph.D., 111 S. Gay St., Baltimore, Md. (30). 1885. **C B**

Lesley, Prof. J. Peter, State Geologist of Pennsylvania, 1008 Clinton St., Philadelphia, Pa. (2). 1874. **E**

Libbey, Prof. William, jr., Princeton, N. J. (29). 1887. **E F**

Lilly, Gen. Wm., Mauch Chunk, Carbon Co., Pa. (28). 1882. (Patron). **F E**

Lindsley, J. Berrien, M.D., 135 North Spruce St., Nashville, Tenn. (1). 1874. **F**

Lintner, J. A., N. Y. State Entomologist, Room 27, Capitol, Albany, N. Y. (22). 1874. **F**

Litton, Abram, 2220 Eugenia St., St. Louis, Mo. (28). 1879. **C**

Lockwood, Samuel, Ph.D., Freehold, Monmouth Co., N. J. (18). 1875. **F B A**

Loomis, Prof. Elias, New Haven, Conn. (1). 1874. **A B**

Loughridge, Dr. R. H., South Carolina College, Columbia, S. C. (21). 1874. **E C**

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Love, Edward G., School of Mines, Columbia College, New York, N. Y. (24). 1882. C
Lovering, Prof. Joseph, Harv. Univ., Cambridge, Mass. (2). 1875. B A
Lupton, Prof. N. T., Auburn, Ala. (17). 1874. C
Lyle, David Alexander, Captain, Ordnance Dept. U. S. A., Ordnance Office, Washington, D. C. (28). 1880. D
Lyman, Prof. Chester S., 88 Trumbull St., New Haven, Conn. (4). 1875. A
Lyon, Dr. Henry, 34 Monument Sq., Charlestown, Mass. (18). 1874.

McCauley, Capt. C. A. H., Ass't Q. M., U. S. A., 321 Michigan Ave., Chicago, Ill. (29). 1881.
McGee, W. J., U. S. Geol. Survey, Washington, D. C. (27). 1882. E
McGill, John T., Ph.D., Vanderbilt Univ., Nashville, Tenn. (36). 1888. C
McLeod, C. H., McGill Univ., Montreal, Can. (35). 1887.
McMurtrie, William, Univ. of Illinois, Champaign, Ill. (22). 1874. C
McNeill, Malcolm, Princeton, N. J. (32). 1885. A
Mabery, Prof. C. F., Case School of Applied Science, Cleveland, Ohio (29). 1881. C
Macfarlane, Prof. A., Univ. of Texas, Austin, Texas (34). 1886. B A
Mackintosh, James B., Consolidated Gas Co., 21st St. and Ave. A, New York, N. Y. (27). 1883. C B
Macloskie, Prof. George, College of New Jersey, Princeton, N. J. (25). 1882. F
Magie, Prof. William F., College of New Jersey, Princeton, N. J. (35). 1887.
Mallery, Col. Garrick, U. S. Army, Bureau of Ethnology, Washington, D. C. (26). 1879. H
Mann, B. Pickman, 1918 Sunderland Place, Washington, D. C. (22). 1874. I F
Marcy, Oliver, LL.D., Evanston, Ill. (10). 1874. E
Markoe, Prof. Geo. F. H., 29 Montrose St., Roxbury, Mass. (29). 1881.
Marsh, Prof. O. C., Yale College, New Haven, Conn. (15). 1874. F H
Martin, Prof. Daniel S., 236 West 4th St., New York, N. Y. (23). 1879. E F
Martin, Prof. H. Newell, Johns Hopkins University, Baltimore, Md. (27). 1880. F H
Martin, Miss Lillie J., High School, Indianapolis, Ind. (32). 1886. F C
Martin, Prof. Wm. J., Davidson College, N. C. (31). 1884. C E
Mason, Prof. Otis T., National Mus., Washington, D. C. (25). 1877. H
Mason, Dr. William P., Prof. Rensselaer Polytechnic Inst., Troy, N. Y. (31). 1886. C
Matthews, Washington, 1262 New Hampshire Ave., cor. 21st St., N. W., Washington, D. C. (37). 1888. H
Maxwell, Rev. Geo. M., Wyoming, Hamilton Co., Ohio (30). 1886. H E
Mayer, Prof. A. M., South Orange, N. J. (19). 1874.
Meehan, Thomas, Germantown, Pa. (17). 1875. F
Mees, Prof. Carl Leo, Columbus, Ohio (24). 1876. B C

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Mendenhall, Prof. T. C., Rose Polytechnic Inst., Terre Haute, Ind. (20). 1874. **B**

Menocal, Aniclto G., C. E., U. S. N., Navy Yard, Washington, D. C. (36). 1888. **D**

Merriam, C. Hart, M.D., Smith. Inst., Washington, D. C. (33). 1885. **F**

Merrill, Frederick J. H., Ph.B., 126 E. 60th St., New York, N. Y. (35). 1887. **E**

Merriman, C. C., 1910 Surf St., Lake View, Chicago, Ill. (29). 1880. **F**

Merriman, Prof. Mansfield, Lehigh University, Bethlehem, Pa. (32). 1885. **A D**

Metz, Charles L., M.D., Madisonville, Hamilton Co., Ohio (30). 1885. **H**

Michael, Mrs. Arthur, 1509 Locust St., Philadelphia, Pa. (33). 1885. **C F**

Michelson, A. A., Master U. S. N., 7 Rockwell St., Cleveland, Ohio (26). 1879. **B**

Mills, T. Wesley, Montreal, Can. (31). 1886. **F H**

Minot, Dr. Charles Sedgwick, 25 Mt. Vernon St., Boston, Mass. (28). 1880. **F**

Minot, Francis, M.D., 65 Marlborough St., Boston, Mass. (29). 1884.

Mitchell, Miss Maria, 87 Green St., Lynn, Mass. (4). 1874.

Mixter, Prof. Wm. G., New Haven, Conn. (30). 1882. **C**

Moore, Prof. J. W., M.D., Lafayette College, Easton, Pa. (22). 1874. **B D A**

Moore, Robert, C.E., 325 Chestnut St., St. Louis, Mo. (33). 1887. **D B I**

Morley, Prof. Edward W., 749 Republic St., Cleveland, Ohio (18). 1876. **C B E**

Morong, Rev. Thomas, Ashland, Mass. (35). 1887. **F**

Morris, Rev. John G., Baltimore, Md. (12). 1874.

Morse, Prof. E. S., Salem, Mass. (18). 1874. **F H**

Morton, H., Stevens Inst. Technology, Hoboken, N. J. (18). 1875. **B C**

Moses, Prof. Thos. F., Urbana Univ., Urbana, Ohio (25). 1883. **H F**

Munroe, Prof. C. E., Chemist to Bureau of Ordnance, U. S. Torpedo Station, Newport, R. I. (22). 1874. **C**

Murdoch, John, Smithsonian Institution, Washington, D. C. (29). 1886. **F H**

Murdock, J. B., Lieut. U. S. N., 24 Alaska St., Roxbury, Mass. (28). 1885. **B**

Murtfeldt, Miss Mary E., Kirkwood, Mo. (27). 1881. **F**

Nason, Frank L., 5 Union St., New Brunswick, N. J. (36) 1888. **E**

Nason, Prof. H. B., Rensselaer Polytechnic Institute, Troy, N. Y. (13). 1874. **C E**

Nelson, Prof. A. B., Centre College, Danville, Ky. (30). 1882. **A B D**

Nelson, Prof. Edward T., Delaware, Delaware Co., Ohio (24). 1877. **E F**

Newberry, Prof. J. S., Columbia College, New York, N. Y. (5). 1875. **E F H I**

Newberry, Prof. Spencer Baird, Ithaca, N. Y. (33). 1887. **C**

Newcomb, Prof. S., Navy Dep't, Washington, D. C. (13). 1874. **A B**

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Newton, Hubert A., New Haven, Conn. (6). 1874. **A**
Nichols, E. L., Ph.D., Cornell Univ., Ithaca, N. Y. (28). 1881. **B C**
Nicholson, Prof. H. H., Box 675, Lincoln, Neb. (36). 1888.
Niles, Prof. W. H., Cambridge, Mass. (16). 1874.
Nipher, Prof. F. E., Washington Univ., St. Louis, Mo. (24). 1876. **B**
Norton, Lewis M., Ph.D., Mass. Institute of Technology, Boston, Mass. (29). 1884. **C**
NORTON, PROF. THOMAS H., Univ. of Cincinnati, Cincinnati, Ohio (35). 1887. **C**
Noyes, Prof. Wm. A., Rose Polytechnic Inst., Terre Haute, Ind. (32). 1885. **C**
Nuttall, Mrs. Zelia, care Peabody Museum, Cambridge, Mass. (35). 1887. **H**

Oliver, Charles A., M.D., 1507 Locust St., Philadelphia, Pa. (33). 1886. **F H B**
Oliver, Prof. James E., P. O. Box 1566, Ithaca, N. Y. (7). 1875. **A B I**
Ordway, Prof. John M., Tulane Univ., New Orleans, La. (9). 1875. **C**
Orton, Prof. Edward, President Ohio Agricultural and Mechanical College, Columbus, Ohio (19). 1875. **E**
Osborn, Henry F., S.D., Princeton, N. J. (29). 1883.
Osborn, Henry Leslie, 3 East 47th St., Hamline, Minn. (29). 1887.
Osborn, Herbert, Ames, Iowa (32). 1884. **F**
Osborne, J. W., 212 Delaware Ave. N. E., Washington, D. C. (22). 1874. **D C B**
Owen, Dr. Richard, New Harmony, Ind. (20). 1874. **E**

Packard, Dr. A. S., 115 Angell St., Providence, R. I. (16). 1875. **F E**
Paine, Cyrus F., 305 Ellwanger & Barry Building, Rochester, N. Y. (12). 1874. **B A**
Paine, Nathaniel, Worcester, Mass. (18). 1874. **H**
Palfray, Hon. Charles W., Salem, Mass. (21). 1874.
Parke, John G., Lt. Col. Corps of Eng'rs, Bv't Maj. Gen. U. S. A., Office of Chief of Engineers, Washington, D. C. (29). 1881. **D**
PARKHURST, HENRY M., Law Stenographer, 25 Chambers St., New York, N. Y. (23). 1874. **A**
Paul, Prof. Henry M., U. S. Naval Observatory, Washington, D. C. (33). 1885. **A B**
Peabody, Cecil H., Ass't Prof. Steam Eng., Mass. Institute Technology, Boston, Mass. (32). 1887. **D**
Peabody, Selim H., Regent University of Illinois, Champaign, Ill. (17). 1885. **D B F**
Peckham, S. F., 159 Olney St., Providence, R. I. (18). 1875. **C B E**
Pedrick, Wm. R., Lawrence, Mass. (22). 1875.
Peet, Rev. Stephen D., Mendon, Ill. (24). 1881. **H**
Peirce, Benj. O., jr., Ass't Prof., Harvard College, Cambridge, Mass. (29). 1886. **A B**

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Pengra, Charles P., M.D., 130 Dartmouth St., Boston, Mass. (34). 1887. **F C**

Perkins, Prof. George H., Burlington, Vt. (17). 1882. **H F E**

Peter, Dr. Robert, Kentucky Geol. Survey, Lexington, Ky. (29). 1881. **C**

Pettee, Prof. William H., Ann Arbor, Mich. (24). 1875. **E**

Philbrick, Edw. S., Brookline, Mass. (29). 1886. **D**

Phillips, A. W., New Haven, Conn. (24). 1879.

Phillips, Henry, jr., 320 So. 11th St., Philadelphia, Pa. (32). 1887. **H I**

Phippen, Geo. D., Salem, Mass. (18). 1874. **F**

Pickering, Prof. E. C., Director of Observatory, Cambridge, Mass. (18). 1875. **A B**

Pickering, William H., Harvard Observatory, Cambridge, Mass. (29). 1883. **B A**

Pilling, James C., Box 591, Washington, D. C. (28). 1882. **F H I**

Pillsbury, Prof. John H., Smith College, Northampton, Mass. (23). 1885. **F H**

Platt, Franklin, Ass't Geologist, 2nd Geol. Survey of Pa., 615 Walnut St., Philadelphia, Pa. (27). 1882. **E**

Pohlman, Dr. Julius, Buffalo, N. Y. (32). 1884. **E F**

Porter, Thos. C., LL.D., Lafayette College, Easton, Pa. (33). 1887. **F**

Powell, Major J. W., U. S. Geologist, 910 M St. N. W., Washington, D. C. (23). 1875. **E H**

Power, Prof. Frederick B., Univ. of Wis., Madison, Wis. (31). 1887. **C**

Prentiss, Prof. A. N., Cornell Univ., Ithaca, N. Y. (35). 1887. **F**

Prentiss, D. Webster, M.D., 1101 14th St. N. W., Washington, D. C. (29). 1882. **F**

Prescott, Prof. Albert B., Ann Arbor, Mich. (23). 1875. **C**

Pritchett, Henry S., Director Observatory Washington University, St. Louis, Mo. (29). 1881. **A**

Procter, John R., Dir. Kentucky Geol. Surv., Frankfort, Ky. (26). 1881.

Pulsifer, Wm. H., St. Louis, Mo. (26). 1879. **A H**

Pumpelly, Prof. Raphael, U. S. Geological Survey, Newport, R. I. (17). 1875. **E I**

Putnam, Prof. F. W., Curator Peabody Museum American Archæology and Ethnology, Cambridge, Mass. (Address as Permanent Secretary A. A. A. S., Salem, Mass.) (10). 1874. **H**

Pynchon, Rev. T. R., Pres. Trinity Coll., Hartford, Conn. (23). 1875.

Quincy, Edmund, 88 Clinton St., Boston, Mass. (11). 1874.

Rauch, Dr. John H., Springfield, Ill. (11). 1875.

Raymond, Rossiter W., 17 Burling Slip, New York, N. Y. (15). 1875. **E I**

Redfield, J. H., 216 W. Logan Square, Philadelphia, Pa. (1). 1874. **F**

Reed, E. Baynes, London, Ontario, Can. (27). 1882.

Rees, Prof. John K., Columbia College, New York, N. Y. (26). 1878. **A E B**

Remsen, Prof. Ira, Johns Hopkins Univ., Baltimore, Md. (22). 1875. **C**

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Rice, John M., U. S. Naval Academy, Annapolis, Md. (25). 1881. **A D**
Rice, Prof. Wm. North, Wesleyan University, Middletown, Conn. (18). 1874. **E F**
Richards, Prof. Charles B., 313 York St., New Haven, Conn. (33). 1885. **D**
Richards, Edgar, Office of Internal Revenue, Treasury Dept., Washington, D. C. (31). 1886. **C**
Richards, Prof. Robert H., Mass. Inst. Tech., Boston, Mass. (22). 1875. **D**
Richards, Mrs. Robert H., Prof. Mass. Inst. of Tech., Boston, Mass. (23). 1878. **C**
Richardson, Clifford, Dep't of Agric., Washington, D. C. (30). 1884. **C**
Ricketts, Prof. Palmer C., Rensselaer Polytechnic Inst., Troy, N. Y. (33). 1887. **D A**
Ricketts, Prof. Pierre de Peyster, School of Mines, Columbia College, New York, N. Y. (26). 1880. **C D E**
Riley, Prof. C. V., U. S. Entomologist, 1700 13th St. N. W., Washington, D. C. (17). 1874. **F H I**
Ritchie, E. S., Newton Highlands, Mass. (10). 1877. **B**
Roberts, Prof. Isaac P., Ithaca, N. Y. (33). 1886. **I**
Robinson, Prof. S. W., Univ. of Ohio, Columbus, Ohio (30). 1883. **D B A**
Rockwell, Gen. Alfred P., Manchester, Mass. (10). 1882. **E**
Rockwell, Chas. H., Box 293, Tarrytown, N. Y. (28). 1883. **A D**
Rockwood, Prof. Charles G., jr., College of New Jersey, Princeton, N. J. (20). 1874. **A E B D**
Rogers, Fairman, Messrs. Dick Bros. & Co., No. 147 S. Fourth St., Philadelphia, Pa. (11). 1874.
Rogers, Prof. W. A., Colby Univ., Waterville, Me. (15). 1875. **A B D**
Rominger, Dr. Carl, Ann Arbor, Mich. (21). 1879. **E**
Rood, Prof. O. N., Columbia College, New York, N. Y. (14). 1875. **B**
Ross, Waldo O., 31 Otis St., Boston, Mass. (29). 1882.
Rowland, Prof. Henry A., Baltimore, Md. (29). 1880.
Runkle, Prof. J. D., Mass. Institute of Technology, Boston, Mass. (2). 1875. **A D**
Russell, I. C., U. S. Geological Survey, Washington, D. C. (25). 1882.
Rutherford, Lewis M., 175 Second Ave., New York, N. Y. (13). 1875.

Sadtler, Prof. Sam'l P., Univ. of Pa., Philadelphia, Pa. (22). 1875. **C**
Safford, Dr. James M., Nashville, Tenn. (6). 1875. **E C F**
Salmon, Daniel E., Dep't of Agric., Washington, D. C. (31). 1885. **F**
Sampson, Commander W. T., U. S. N., Naval Acad., Annapolis, Md. (25). 1881. **B A**
Sanborn, Jeremiah Wilson, Agric. Coll., Columbia, Mo. (31). 1886.
Sanborn, Rev. John W., Lockport, N. Y. (33). 1886. **H**
Saunders, William, Director Agricultural Experiment Station, Ottawa, Canada (17). 1874. **F**
Schaeberle, J. M., Astronomer in the Lick Observatory, San José, Cal. (34). 1886. **A**

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Schanck, Prof. J. Stillwell, Princeton, New Jersey (4). 1882. C B H
Schott, Charles A., U. S. Coast and Geodetic Survey Office, Washington, D. C. (8). 1874. A
Schweitzer, Prof. Paul, State University of Missouri, Columbia, Mo. (24). 1877. C B
Scott, Prof. Wm. B., Princeton, N. J. (33). 1887. F E
Scovell, M. A., Director Kentucky Agricultural Experiment Station, Lexington, Ky. (35). 1887.
SCUDDER, SAMUEL H., Cambridge, Mass. (13). 1874. F
Seaman, W. H., Microscopist, 1424 11th St. N. W., Washington, D. C. (23). 1874. C F
Sedgwick, Prof. Wm. T., Massachusetts Institute of Technology, Boston, Mass. (33). 1886. F
See, Horace, 1230 Spruce St., Philadelphia, Pa. (34). 1886. D
Seiler, Carl, M.D., 1346 Spruce St., Philadelphia, Pa. (29). 1882. F B
Sewall, Prof. Henry, Univ. of Mich., Ann Arbor, Mich. (34). 1885. F
Sharples, Stephen P., 13 Broad St., Boston, Mass. (29). 1884. C
Sharpless, Prof. Isaac, Haverford College, Pa. (33). 1888. A
Sheafer, P. W., Pottsville, Pa. (4). 1879. E
Sigsbee, Chas. D., Comd'r U. S. N., U. S. Naval Acad., Annapolis, Md. (28). 1882. D E
Silliman, Prof. Justus M., Lafayette Coll., Easton, Pa. (19). 1874. D E
Skinner, Joseph J., Massachusetts Inst. Technology, Boston, Mass. (23). 1880. B
Smiley, Charles W., U. S. Fish Commission, Washington, D. C. (28). 1883. I
Smith, Prof. Chas. J., 35 Adelbert St., Cleveland, Ohio (32). 1885. A B
Smith, Edwin, Ass't U. S. Coast and Geodetic Survey, Washington, D. C. (30). 1882. A B
Smith, Prof. Erastus G., Beloit College, Beloit, Wis. (34). 1887. C
Smith, Prof. Eugene A., University, Ala. (20). 1877. E C
Smith, Prof. Francis H., University of Virginia, Charlottesville, Va. (26). 1880. B A
Smith, John B., National Museum, Washington, D. C. (32). 1884. F
SMITH, QUINTIUS C., M.D., No. 617 Colorado St., Austin, Texas (26). 1881. F
Smith, Prof. S. I., Yale College, New Haven, Conn. (18). 1875. F
Smith, Dr. Theobald, Bureau of Animal Industry, U. S. Dep't of Agric., Washington, D. C. (35). 1887. F
Smock, Prof. John Conover, New York State Museum, Albany, N. Y. (23). 1879. E
Snow, Prof. F. H., Lawrence, Kan. (29). 1881. F E
Snyder, Henry, B.Sc., Miami Univ., Oxford, Ohio. (30). 1888. B C
Snyder, Prof. Monroe B., High School Observatory, Philadelphia, Pa. (24). 1882. A B
Soule, R. H., Gen. Agent, The Union Switch & Signal Co., Pittsburgh, Pa. (33). 1886. D

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Spalding, Volney M., Ann Arbor, Mich. (34). 1886. **F**

Spencer, Prof. J. William, Prof. of Geology, University of Georgia, Athens, Ga. (28). 1882. **E**

Springer, Dr. Alfred, Box 621, Cincinnati, Ohio (24). 1880. **C**

Staley, Cady, LL.D., Pres. Case School of Applied Sciences, Cleveland, Ohio (37). 1888. **D**

Stearns, R. E. C., care Smithsonian Institution, Washington, D. C. (18). 1874. **F**

Steiner, Dr. Lewis H., Enoch Pratt Free Library, Baltimore, Md. (7). 1874. **I**

Stephens, W. Hudson, Lowville, N. Y. (18). 1874. **E H**

Sternberg, George M., Surgeon U. S. A., Johns Hopkins Univ., Baltimore, Md. (24). 1880. **F**

Stevens, W. LeConte, 170 Joralemon St., Brooklyn, N. Y. (29). 1882. **B A C**

Stevenson, Prof. John J., Univ. of New York, New York, N. Y. (36). 1888.

Stockwell, John N., 1008 Case Avenue, Cleveland, Ohio (18). 1875. **A**

Stone, George H., Colorado Springs, Col. (29). 1882. **E F**

Stone, Mrs. Leander, 3417 Indiana Avenue, Chicago, Ill. (22). 1874. **F E**

Stone, Ormond, Director Leander McCormick Observatory, University of Virginia, Va. (24). 1876. **A**

Storrs, Henry E., Jacksonville, Ill. (20). 1874. **C E**

Story, Wm. E., Johns Hopkins Univ., Baltimore, Md. (29). 1881. **A**

Stowell, Prof. T. B., Cortland, Cortland Co., N. Y. (28). 1885. **F**

Stringham, Prof. Irving, Univ. of Cal., Berkeley, Cal. (33). 1885. **A**

Stuart, Prof. A. P. S., Lincoln, Nebraska (21). 1874. **C**

Sturtevant, E. Lewis, M.D., Geneva, N. Y. (29). 1882. **F**

Swift, Lewis, Ph.D., Rochester, N. Y. (29). 1882. **A**

Tainter, Sumner, 2020 F St. N. W., Washington, D. C. (29). 1881. **B D A.**

Taylor, Thos., M.D., Dep't of Agric., Washington, D. C. (29). 1885. **F C**

Taylor, William B., Smithsonian Institution, Washington, D. C. (29). 1881. **B A**

Terry, Prof. N. M., U. S. Naval Academy, Annapolis, Md. (23). 1874. **B**

Thomas, Benj. F., Ph.D., State Univ., Columbus, Ohio (29). 1882. **B A**

Thomson, Elihu, Thomson-Houston Electric Co., Lynn, Mass. (37). 1888. **B**

Thomson, Wm., M.D., 1426 Walnut St., Philadelphia, Pa. (33). 1885. **B**

Thurston, Prof. R. H., Sibley College, Cornell University, Ithaca, N. Y. (23). 1875. **D**

Tittmann, Otto H., U. S. Coast and Geodetic Survey Office, Washington, D. C. (24). 1888. **A**

Todd, Prof. David P., Director Lawrence Observatory, Amherst College, Amherst, Mass. (27). 1881. **A B D**

Todd, Prof. James E., Tabor, Fremont Co., Iowa (22). 1886. **E F**

Towne, Henry R., Pres. Yale and Towne Manufacturing Co., Stamford, Conn. (33). 1888. **D B**

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Townshend, Prof. N. S., Ohio State Univ., Columbus, Ohio (17). 1881. **F H**
Tracy, Sam'l M., Agricultural College, Miss. (27). 1881. **F**
Trembley, J. B., M.D., 952 8th St., Oakland, Alameda Co., Cal. (17). 1880. **B F**
Trowbridge, Prof. W. P., School of Mines, Columbia College, New York, N. Y. (10). 1874. **D**
True, Fred W., U. S. National Museum, Washington, D. C. (28). 1882. **F**
Trumbull, Dr. J. Hammond, Hartford, Conn. (29). 1882. **H**
Tucker, Willis G., M.D., Albany Med. Coll., Albany, N. Y. (29). 1888. **C**
Tuttle, Prof. Albert H., Univ. of Virginia, Va. (17). 1874. **F**

Uhler, Philip R., 218 W. Hoffman St., Baltimore, Md. (19). 1874. **F E**
Underwood, Prof. Lucien M., cor. Comstock Ave. and Marshall St., Syracuse, N. Y. (33). 1885. **F**
Upham, Warren, 21 Newbury St., Somerville, Mass. (25). 1880. **E**
Upton, Winslow, Brown Univ., Providence, R. I. (29). 1883. **A**

Van der Weyde, P. H., M.D., 236 Duffield St., Brooklyn, N. Y. (17). 1874. **B**
Van Dyck, Prof. Francis Cuyler, New Brunswick, N. J. (28). 1882. **B C F**
Van Vleck, Prof. John M., Middletown, Conn. (23). 1875. **A**
Vaughn, Dr. Victor C., Ann Arbor, Mich. (34). 1887. **C**
Very, Samuel W., Lieut. Comdr. U. S. N., U. S. S. Santee, Naval Acad., Annapolis, Md. (28). 1886. **A B**
Vining, Edward P., N. Y. & N. E. R. R. Co., 246 Federal St., Boston, Mass. (32). 1887. **H**
Vogdes, A. W., 1st Lt. 5th Art'y U. S. A., The Military Service Inst., Governor's Island, N. Y. (32). 1885. **E F**

Wachsmuth, Charles, 111 Marietta St., Burlington, Iowa (30). 1884. **E F**
Wadsworth, Prof. M. Edward, Ph.D., Director of the Michigan Mining School, State Geologist of Michigan, Houghton, Mich. (23). 1874. **E**
Walcott, Charles D., U. S. Geological Survey, Washington, D. C. (25). 1882. **E F**
Waldo, Leonard, S.D., Lockport, N. Y. (28). 1880. **A**
Wallace, Wm., Ansonia, Conn. (28). 1882.
Waller, E., School of Mines, Columbia College, New York, N. Y. (23). 1874.
Walmsley, W. H., 1016 Chestnut St., Philadelphia, Pa. (28). 1883. **F**
Ward, Prof. Henry A., Rochester, N. Y. (13). 1875. **F E H**
Ward, Lester F., U. S. Geological Survey, Washington, D. C. (26). 1879. **E F**
Ward, Dr. R. H., 53 Fourth St., Troy, N. Y. (17). 1874. **F B**
Warder, Prof. Robert B., Howard Univ., Washington, D. C. (19). 1881. **C B**
Warner, James D., 199 Baltic St., Brooklyn, N. Y. (18). 1874. **A B**

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Warren, Cyrus M., Brookline, Mass. (29). 1882. C
Warren, Dr. Joseph W., 119 Boylston St., Boston, Mass. (31). 1886. F
Warren, Prof. S. Edward, Newton, Mass. (17). 1875. A—I
Watson, Sereno, Botanic Gardens, Cambridge, Mass. (22). 1875. F
Watson, Prof. Wm., 107 Marlborough St., Boston, Mass. (12). 1884. A
Wead, Prof. Charles K., Hartford, Conn. (23). 1880. B
Webb, Prof. J. Burkitt, Stevens Inst., Hoboken, N. J. (31). 1883. D B A
Weber, Prof. Henry A., Ohio State Univ., Columbus, Ohio. (35). 1888. F
Webster, Prof. N. B., Park Ave., Norfolk, Va. (7). 1874. B C E
Wells, Daniel H., Hartford, Conn. (18). 1875. A I
Wendell, Oliver C., Observatory, Cambridge, Mass. (29). 1886.
Westcott, O. S., Maywood, Cook Co., Ill. (21). 1874. H F A
Weston, Edward, 645 High St., Newark, N. J. (33). 1887. B C D
Wheatland, Dr. Henry, President Essex Inst., Salem, Mass. (1). 1874.
Wheeler, Prof. C. Gilbert, 81 Clark St., Chicago, Ill. (18). 1883. C E
Wheeler, Orlando B., 343 N. 18th St., Philadelphia, Pa. (24). 1882. A D
Wheildon, W. W., Box 229, Concord, Mass. (13). 1874. B E
White, Prof. C. A., Le Droit Park, Washington, D. C. (17). 1875. E F
White, Prof. H. C., Univ. of Georgia, Athens, Ga. (29). 1885. C
White, Prof. I. C., Univ. of W. Va., Morgantown, W. Va. (25). 1882. E
Whiteaves, J. F., Geological Survey, Ottawa, Can. (31). 1887. E F
Whitfield, R. P., American Museum Natural History, 77th St. & 8th Avenue, New York, N. Y. (18). 1874. E F H
Whiting, Miss Sarah F., Wellesley College, Wellesley, Mass. (31). 1883. B A
Whitman, Prof. Frank P., Adelbert College, Cleveland, Ohio (33). 1885.
Wilber, G. M., Pine Plains, N. Y. (19). 1874. F H
Wilbur, A. B., Middletown, N. Y. (23). 1874.
Wilder, Prof. Burt G., Cornell University, Ithaca, N. Y. (22). 1875. F
Wiley, Prof. Harvey W., Dep't of Agric., Washington, D.C. (21). 1874. C
Williams, Benezette, 171 La Salle St., Chicago, Ill. (33). 1887. D
Williams, Charles H., M.D., 7 Otis Place, Boston, Mass. (22). 1874.
Williams, Geo. Huntington, Johns Hopkins Univ., Baltimore, Md. (33). 1886. E
Williams, Henry Shaler, Cornell Univ., Ithaca, N. Y. (18). 1882. E F
Williams, Prof. Henry W., 15 Arlington St., Boston, Mass. (11). 1874. H F
Williams, Prof. S. G., Cornell Univ., Ithaca, N. Y. (33). 1885. E
Willson, Prof. Frederick N., Princeton, N. J. (33). 1887. A D
Wilson, Prof. Daniel, President University College, 117 Bloor St., Toronto, Canada (25). 1876. H E
Wilson, H. C., U. S. Naval Observatory, Washington, D. C. (30). 1885. A
Wilson, Joseph M., Room 1036, Drexel Building, Philadelphia, Pa. (33). 1886. D
Wilson, Thomas, U. S. Nat'l Museum, Washington, D. C. (36). 1888. H
Winchell, Prof. Alex., Ann Arbor, Mich. (3). 1875. E

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Winchell, Prof. N. H., Univ. of Minnesota, Minneapolis, Minn. (19). 1874. **E H**

Winlock, Wm. C., U. S. N. Observ., Washington, D. C. (33). 1885. **A B**

Woerd, Chas. V., Am. Watch Co., Waltham, Mass. (29). 1881. **D A**

Wood, Prof. De Volson, Hoboken, N. J. (29). 1881.

Woodbury, C. J. H., 31 Milk St., Boston, Mass. (29). 1884. **D**

Woodward, Prof. Calvin M., 1761 Missouri Ave., St. Louis, Mo. (32). 1884. **D A I**

Woodward, R. S., care of U. S. Geol. Survey, Washington, D. C. (33). 1885. **A B D**

Wormley, T. G., Univ. of Pennsylvania, Philadelphia, Pa. (20). 1878.

Worthen, W. E., 63 Bleeker St., New York, N. Y. (36). 1888. **D**

Wrampelmeier, Theo. J., San Diego, Cal. (34). 1887. **C**

Wright, Prof. Albert A., Oberlin College, Oberlin, Ohio (24). 1880. **E F**

Wright, Prof. Arthur W., Yale Coll., New Haven, Conn. (14). 1874. **A B**

Wright, Rev. Geo. F., Oberlin College, Oberlin, Ohio (29). 1882. **E**

Würtele, Rev. Louis C., Acton Vale, Province of Quebec, Can. (11). 1875. **E**

Young, A. V. E., Northwestern Univ., Evanston, Ill. (33). 1886. **C B**

Young, C. A., Prof. of Astronomy, College of New Jersey, Princeton, N. J. (18). 1874. **A B D**

Zentmayer, Joseph, 147 S. Fourth St., Philadelphia, Pa. (29). 1882. **F**

[690 FELLOWS.]

SUMMARY.—PATRONS, 3; MEMBERS, 1271; HONORARY FELLOW, 1; FELLOWS, 689.

APRIL 12, 1889. TOTAL NUMBER OF MEMBERS OF THE ASSOCIATION, 1964.

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DECEASED MEMBERS.

[Unless by special vote of the Council, the names of those only who are members of the Association at the *time of their decease* will be included in this list. Information of the date and place of birth and death, to fill blanks in this list, is requested by the Permanent Secretary.]

Abbe, George W., New York, N. Y. (23). Died Sept. 25, 1879.

Abert, John James, Washington, D. C. (1). Born in Shepherdstown, Va., Sept. 17, 1788. Died in Washington, D. C., Sept. 27, 1863.

Adams, Charles Baker, Amherst, Mass. (1). Born in Dorchester, Mass., Jan. 11, 1814. Died in St. Thomas, W. I., Jan. 19, 1853.

Adams, Edwin F., Charlestown, Mass. (18).

Adams, Samuel, Jacksonville, Ill. (18). Born Dec. 19, 1806. Died April 29, 1877.

Agassiz, Louis, Cambridge, Mass. (1). Born in Parish of Motier, Switzerland, May 28, 1807. Died in Cambridge, Mass., Dec. 14, 1873.

Ainsworth, J. G., Barry, Mass. (14).

Alexander, Stephen, Princeton, N. J. (1). Born Sept. 1, 1806. Died June 25, 1883.

Allen, Thomas, St. Louis, Mo. (27). Died April 8, 1882.

Allen, Zachariah, Providence, R. I. (1). Born in Providence, R. I., Sept. 15, 1795. Died March 17, 1882.

Allston, Robert Francis Withers, Georgetown, S. C. (3). Born in All Saints Parish, S. C., April 21, 1801. Died near Georgetown, S. C., April 7, 1864.

Alvord, Benjamin, Washington, D. C. (17). Born in Rutland, Vt., Aug. 18, 1813. Died Oct. 16, 1884.

Ames, M. P., Springfield, Mass. (1). Born in 1803. Died April 23, 1847.

Andrews, Ebenezer Baldwin, Lancaster, Ohio (7). Born in Danbury, Conn., April 29, 1821. Died in Lancaster, Ohio, Aug. 14, 1880.

Anthony, Charles H., Albany, N. Y. (6). Died in 1874.

Appleton, Nathan, Boston, Mass. (1). Born in New Ipswich, N. H., Oct. 6, 1779. Died July 14, 1861.

Armstrong, John W., Fredonia, N. Y. (24).

Ashburner, Wm., San Francisco, Cal. (29). Born in Stockbridge, Mass., March, 1831. Died in San Francisco, Cal., April 20, 1887.

Atwater, Mrs. S. T., Chicago, Ill. (17). Born Aug. 8, 1812. Died April 11, 1878.

Aufrecht, Louis, Cincinnati, Ohio (30).

Bache, Alexander Dallas, Washington, D. C. (1). Born in Philadelphia, Pa., July 19, 1806. Died at Newport, R. I., Feb. 17, 1867.

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Bache, Franklin, Philadelphia, Pa. (1). Born in Philadelphia, Pa., Oct. 25, 1792. Died March 19, 1864.

Bailey, Jacob Whitman, West Point, N. Y. (1). Born in Auburn, Mass., April 29, 1811. Died in West Point, N. Y., Feb. 26, 1857.

Baird, Spencer Fullerton, Washington, D. C. (1). Born in Reading, Pa., Feb. 3, 1823. Died in Wood's Holl, Mass., Aug. 19, 1887.

Bardwell, F. W., Lawrence, Kan. (13). Died in 1878.

Barnard, John Gross, New York, N. Y. (14). Born in Sheffield, Mass., May 19, 1815. Died in Detroit, Mich., May 14, 1882.

Barrett, Moses, Milwaukee, Wis. (21). Died in 1873.

Barry, Redmond, Melbourne, Australia (25).

Bassett, Daniel A., Los Angeles, Cal. (29). Born Dec. 8, 1819. Died May 26, 1887.

Bassnett, Thomas, Jacksonville, Fla. (8). Born 1807. Died in Jacksonville, Fla., Feb. 16, 1886.

Bayne, Herbert Andrew, Kingston, Ont., Can. (29). Born in London, derry, Nova Scotia, Aug. 16, 1846. Died in Pictou, Can., Sept. 16, 1886.

Beach, J. Watson, Hartford, Conn. (23). Born Dec. 28, 1823. Died Mar. 16, 1887.

Beck, C. F., Philadelphia, Pa. (1).

Beck, Lewis Caleb, New Brunswick, N. J. (1). Born in Schenectady, N. Y., Oct. 4, 1798. Died April 20, 1853.

Beck, Theodoric Romeyn, Albany, N. Y. (1). Born in Schenectady, N. Y., Aug. 11, 1791. Died in Utica, N. Y., Nov. 19, 1855.

Beckwith, Henry C., Coleman's Station, N. Y. (29). Died July 12, 1885.

Belfrage, G. W., Clifton, Texas (29). Died Dec. 7, 1882.

Belt, Thomas, London, Eng. (27). Died Sept. 8, 1878.

Benedict, George Wyllys, Burlington, Vt. (16). Born Jan. 11, 1796. Died Sept. 23, 1871.

Bicknell, Edwin, Boston, Mass. (18). Born in 1830. Died March 19, 1877.

Binney, Amos, Boston, Mass. (1). Born in Boston, Mass., Oct. 18, 1803. Died in Rome, Feb. 18, 1847.

Binney, John, Boston, Mass. (3).

Blackie, Geo. S., Nashville, Tenn. (26).

Blair, Henry W., Washington, D. C. (26). Died Dec. 15, 1884.

Blake, Eli Whitney, New Haven, Conn. (1). Born Jan. 27, 1795. Died Aug. 18, 1886.

Blake, Homer Crane, New York, N. Y. (28). Born in Cleveland, Ohio, Feb. 1, 1822. Died in New York, N. Y., Jan. 20, 1880.

Blanding, William, ———, R. I. (1).

Blatchford, Thomas W., Troy, N. Y. (6).

Blatchley, Miss S. L., New Haven, Conn. (19). Died March 13, 1873.

Boadle, John, Haddonfield, N. J. (20). Born in 1805. Died in July, 1878.

Bomford, George, Washington, D. C. (1). Born in New York, 1780. Died in Boston, Mass., March 25, 1848.

Bowles, Miss Margaretta, Columbia, Tenn. (26). Died July, 1887.

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Bowron, James, South Pittsburg, Tenn. (26). Died in Dec., 1877.
Bradley, Leverette, Jersey City, N. J. (15). Died in 1875.
Braithwaite, Jos., Chambly, C. W. (11).
Briggs, Albert D., Springfield, Mass. (13). Died Feb. 20, 1881.
Briggs, Robert, Philadelphia, Pa. (29). Born May 18, 1822. Died July 24, 1882.
Brigham, Charles Henry, Ann Arbor, Mich. (17). Born in Boston, Mass., July 27, 1820. Died Feb. 19, 1879.
Brown, Andrew, Natchez, Miss. (1).
Brown, Horace, Salem, Mass. (27). Died in July, 1883.
Bull, John, Washington, D. C. (31). Born Aug. 1, 1819. Died June 9, 1884.
Burbank, L. S., Woburn, Mass. (18).
Burke, Joseph Chester, Middletown, Conn. (29). Died in 1885.
Burnap, George Washington, Baltimore, Md. (12). Born in Merrimack, N. H., Nov. 30, 1802. Died in Philadelphia, Pa., Sept. 8, 1859.
Burnett, Waldo Irving, Boston, Mass. (1). Born in Southborough, Mass., July 12, 1828. Died in Boston, Mass., July 1, 1854.
Butler, Thomas Belden, Norwalk, Conn. (10). Born Aug. 22, 1806. Died June 8, 1873.

Cairns, Frederick A., New York, N. Y. (27). Died in 1879.
Campbell, Mrs. Mary H., Crawfordsville, Ind. (22). Died Feb. 27, 1882.
Carpenter, Thornton, Camden, S. C. (7).
Carpenter, William M., New Orleans, La. (1).
Case, Leonard, Cleveland, Ohio (15). Born June 27, 1820. Died Jan. 5, 1880.
Case, William, Cleveland, Ohio (6).
Caswell, Alexis, Providence, R. I. (2). Born Jan. 29, 1799. Died in Providence, R. I., Jan. 8, 1877.
Chadbourne, Paul Ansel, Amherst, Mass. (10). Born in North Berwick, Me., Oct. 21, 1823. Died Feb. 23, 1883.
Chapman, Nathaniel, Philadelphia, Pa. (1). Born in Alexandria Co., Va., May 28, 1780. Died July 1, 1853.
Chase, Pliny Earle, Haverford College, Pa. (18). Born in Worcester, Mass., Aug. 18, 1820.
Chase, Stephen, Hanover, N. H. (2). Born in 1813. Died Aug. 5, 1851.
Chauvenet, William, St. Louis, Mo. (1). Born May 24, 1819. Died Dec. 13, 1870.
Cheesman, Louis Montgomery, Hartford, Conn. (32). Born in 1858. Died in Jan., 1885.
Cheney, Miss Margaret S., Jamaica Plain, Mass. (29). Died in 1882.
Chevreul, Michel Eugène, Paris, France (35). Born in Angiers, France, Aug. 31, 1786. Died in April, 1889.
Clapp, Asahel, New Albany, Ind. (1). Born Oct. 5, 1792. Died Dec. 15, 1862.
Clark, Henry James, Cambridge, Mass. (13). Born in Easton, Mass., June 22, 1826. Died in Amherst, Mass., July 1, 1873.

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Clark, Joseph, Cincinnati, Ohio (5).
Clark, Patrick, Rahway, N. J. (33). Died March 5, 1887.
Clarke, A. B., Holyoke, Mass. (13).
Cleaveland, C. H., Cincinnati, Ohio (9).
Cleveland, A. B., Cambridge, Mass. (2).
Coffin, James Henry, Easton, Pa. (1). Born in Northampton, Mass., Sept. 6, 1806. Died Feb. 6, 1873.
Cole, Frederick, Montreal, Can. (31). Died in 1887.
Cole, Thomas, Salem, Mass. (1). Born Dec. 24, 1779. Died June 24, 1852.
Coleman, Henry, Boston, Mass. (1).
Collins, Frederick, Washington, D. C. (28). Born Dec. 5, 1842. Died Oct. 27, 1881.
Conrad, Timothy Abbott, Philadelphia, Pa. (1). Born in New Jersey, June, 21, 1803. Died Aug 9, 1877.
Cooke, Caleb, Salem, Mass. (18). Born Feb. 15, 1838. Died June 5, 1880.
Cooper, William, Hoboken, N. J. (9). Died in 1864.
Copes, Joseph S., New Orleans, La. (11). Born Dec. 9, 1811. Died March 1, 1885.
Corning, Erastus, Albany, N. Y. (6). Born in Norwich, Conn., Dec. 14, 1794. Died April 9, 1872.
Costin, M. P., Fordham, N. Y. (30). Died June 8, 1884.
Couper, James Hamilton, Darien, Ga. (1). Born March 5, 1794. Died July 3, 1866.
Cramp, John Mockett, Wolfville, N. S. (11). Born in Kent, England, July 25, 1796. Died Dec. 6, 1881.
Crehore, John D., Cleveland, Ohio (24).
Crocker, Charles F., Lawrence, Mass. (22). Died in July, 1881.
Crocker, Miss Lucretia, Boston, Mass. (29). Died in 1886.
Crosby, Alpheus, Salem, Mass. (10). Born in Sandwich, N. H., Oct. 13, 1810. Died April 17, 1874.
Crosby, Thomas Russell, Hanover, N. H. (18). Born Oct. 22, 1816. Died March 1, 1872.
Croswell, Edwin, Albany, N. Y. (6). Born in Catskill, N. Y., May 29, 1797. Died June 13, 1871.
Crow, Wayman, St. Louis, Mo. (27). Born March 7, 1808. Died May 10, 1885.
Curry, W. F., Geneva, N. Y. (11).
Curtis, Josiah, Washington, D. C. (18). Died Aug. 1, 1883.

Dalrymple, E. A., Baltimore, Md. (11). Died Oct. 30, 1881.
Davenport, H. W., Washington, D. C. (30).
Dayton, Edwin A., Madrid, N. Y. (7). Born in 1827. Died June 24, 1873.
Dean, Amos, Albany, N. Y. (6). Born in Barnard, Vt., Jan. 16, 1803. Died Jan. 26, 1868.
Dearborn, George H. A. S., Roxbury, Mass. (1).
Dekay, James Ellsworth, New York, N. Y. (1). Born in New York, 1792. Died Nov. 21, 1851.

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Delano, Joseph C., New Bedford, Mass. (5). Born Jan. 9, 1796. Died Oct. 16, 1886.

DeLaski, John, Carver's Harbor, Me. (18).

Devereux, John Henry, Cleveland, Ohio (18). Born in Boston, Mass., April 5, 1832. Died in Cleveland, Ohio, March 17, 1886.

Dewey, Chester, Rochester, N. Y. (1). Born in Sheffield, Mass., Oct. 25, 1781. Died Dec. 15, 1867.

Dexter, G. M., Boston, Mass. (11).

Dillingham, W. A. P., Augusta, Me. (17).

Dimmick, L. N., Santa Barbara, Cal. (29). Died May 31, 1884.

Dinwiddie, Hardaway H., College Station, Texas (32). Died Dec. 11, 1887.

Dixwell, Geo. B., Boston, Mass. (29). Died April, 1885.

Doggett, George Newell, Chicago, Ill. (33). Born in Chicago, Ill., Dec. 19, 1858. Died in Fredericksburg, Va., Jan. 15, 1887.

Doggett, Mrs. Kate Newell, Chicago, Ill. (17). Born in Castleton, Vt., Nov. 5, 1828. Died in Havana, Cuba, March 13, 1884.

Doggett, Wm. E., Chicago, Ill. (17). Born Nov. 20, 1820. Died in 1876.

Doolittle, L., Lenoxville, C. E. (11). Died in 1862.

Dorr, Ebenezer Pearson, Buffalo, N. Y. (25). Born in Hartford, Vt. Died in Buffalo, N. Y., April 29, 1882.

Draper, Henry, New York, N. Y. (28). Born in New York, N. Y., March 7, 1837. Died Nov. 20, 1882.

Ducatel, Julius Timoleon, Baltimore, Md. (1). Born in Baltimore, Md., June 6, 1798. Died April 25, 1849.

Duffield, George, Detroit, Mich. (10). Born in Strasburg, Pa., July 4, 1794. Died in Detroit, Mich., June 26, 1869.

Dumont, A. H., Newport, R. I. (14).

Dun, Walter Angus, Cincinnati, Ohio (31). Born March 1, 1857. Died Nov. 7, 1887.

Duncan, Lucius C., New Orleans, La. (10). Born in 1801. Died Aug. 9, 1855.

Dunn, R. P., Providence, R. I. (14).

Eads, James Buchanan, New York, N. Y. (27). Born May 23, 1820. Died March 8, 1887.

Easton, Norman, Fall River, Mass. (14). Died Dec. 21, 1872.

Eaton, James H., Beloit, Wis. (17). Died Jan. 5, 1877.

Elliott, Ezekiel Brown, Washington, D. C. (10). Born July 16, 1823. Died May 24, 1888.

Elsberg, Louis, New York, N. Y. (23). Born in Iserlohn, Prussia, April 2, 1836. Died in New York, N. Y., Feb. 19, 1885.

Elwyn, Alfred Langdon, Philadelphia, Pa. (1). Born in Portsmouth, N. H., July 9, 1804. Died in Philadelphia, Pa., March 15, 1884.

Ely, Charles Arthur, Elyria, Ohio (4).

Emerson, Geo. Barrell, Boston, Mass. (1). Born in Kennebunk, Me., Sept. 12, 1797. Died March 14, 1881.

Emmons, Ebenezer, Williamstown, Mass. (1). Born in Middlefield, Mass., May 16, 1799. Died October 1, 1863.

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Engelmann, George, St. Louis, Mo. (1). Born in Frankfort-on-the Main, Germany, Feb. 2, 1809. Died Feb. 4, 1844.

Engstrom, A. B., Burlington, N. J. (1).

Eustis, Henry Lawrence, Cambridge, Mass. (2). Born Feb. 1, 1819. Died Jan. 11, 1885.

Everett, Edward, Boston, Mass. (2). Born in Dorchester, Mass., April 11, 1794. Died in Boston, Mass., Jan. 15, 1865.

Ewing, Thomas, Lancaster, Ohio (5). Born in Ohio Co., Va., Dec. 28, 1789. Died Oct. 26, 1871.

Faries, R. J., Wauwatosa, Wis. (21). Died May 31, 1878.

Farquharson, Robert James, Des Moines, Iowa (24). Born July 15, 1824. Died Sept. 6, 1884.

Ferris, Isaac, New York, N. Y. (6). Born in New York, Oct. 9, 1798. Died in Roselle, N. J., June 16, 1873.

Feuchtwanger, Lewis, New York, N. Y. (11). Born in Fürth, Bavaria, Jan. 11, 1805. Died in New York, N. Y., June 25, 1876.

Fillmore, Millard, Buffalo, N. Y. (7). Born in New York, Jan. 7, 1800. Died March 8, 1874.

Fisher, Mark, Trenton, N. J. (10).

Fitch, Alexander, Hartford, Conn. (1). Born March 25, 1799. Died Jan. 20, 1859.

Fitch, O. H., Ashtabula, Ohio (7). Born in 1803. Died Sept. 17, 1882.

Foote, Herbert Carrington, Cleveland, Ohio (35). Born in 1852. Died Aug. 24, 1888.

Forbush, E. B., Buffalo, N. Y. (15).

Force, Peter, Washington, D. C. (4). Born in New Jersey, Nov. 26, 1790. Died in Washington, D. C., Jan. 23, 1868.

Ford, A. C., Nashville, Tenn. (26).

Forshey, Caleb Goldsmith, New Orleans, La. (21). Born in Somerset Co., Pa., July 18, 1812. Died in Carrollton, La., July 25, 1881.

Foster, John Wells, Chicago, Ill. (1). Born in Brimfield, Mass., March 4, 1815. Died in Chicago, Ill., June 29, 1873.

Foucon, Felix, Madison, Wis. (18).

Fowle, Wm. Bentley, Boston, Mass. (1). Born in Boston, Mass., Oct. 17 1795. Died Feb. 6, 1865.

Fox, Charles, Grosse Ile, Mich. (7).

Frazer, John Fries, Phila., Pa. (1). Born July 8, 1812. Died Oct. 12, 1872.

Freeman, Spencer Hedden, Cleveland, Ohio (29). Born Oct. 3, 1855. Died Feb. 2, 1886.

French, John William, West Point, N. Y. (11). Born in Connecticut, about 1810. Died in West Point, N. Y., July 8, 1871.

Garber, A. P., Columbia, Pa. (29). Died Aug. 26, 1881.

Gavit, John E., New York, N. Y. (1). Born in New York, Oct. 29, 1819. Died in Stockbridge, Mass., Aug. 25, 1874.

Gay, Martin, Boston, Mass. (1). Born in 1804. Died Jan. 12, 1850.

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Gibbon, J. H., Charlotte, N. C. (3).
Gillespie, William Mitchell, Schenectady, N. Y. (10). Born in New York, N. Y., 1816. Died in New York, Jan. 1, 1868.
Gilmor, Robert, Baltimore, Md. (1).
Glazier, W. W., Key West, Fla. (29). Died Dec. 11, 1880.
Goldmark, J., New York, N. Y. (29). Died in April, 1882.
Gould, Augustus Addison, Boston, Mass. (11). Born April 23, 1805. Died Sept. 15, 1866.
Gould, Benjamin Apthorp, Boston, Mass. (2). Born in Lancaster, Mass., June 15, 1787. Died Oct. 24, 1859.
Graham, James D., Washington, D. C. (1). Born in Virginia, 1799. Died in Boston, Mass., Dec. 28, 1865.
Gray, Alonzo, Brooklyn, N. Y. (13). Born in Townshend, Vt., Feb. 21, 1808. Died in Brooklyn, N. Y., March 10, 1860.
Gray, Asa, Cambridge, Mass. (1). Born in Paris, N. Y., Nov. 18, 1810. Died in Cambridge, Mass., Jan. 30, 1888.
Gray, James H., Springfield, Mass. (6).
Greene, Benjamin D., Boston, Mass. (1). Died Oct. 14, 1862, aged 68.
Greene, Everett W., Madison, N. J. (10). Died in 1864.
Greene, Samuel, Woonsocket, R. I. (9). Died in 1868.
Greer, James, Dayton, Ohio (20). Died in Feb., 1874.
Griffith, Robert Eglesfield, Philadelphia, Pa. (1). Born in Philadelphia, Pa., Feb. 13, 1798. Died June 26, 1854.
Griswold, John Augustus, Troy, N. Y. (19). Born Nov. 11, 1818. Died Oct. 31, 1872.
Guest, William E., Ogdensburg, N. Y. (6).
Guyot, Arnold, Princeton, N. J. (1). Born Sept. 5, 1809. Died Feb. 8, 1884.

Habel, Louis, Northfield, Vt. (34).
Hackley, Charles William, New York, N. Y. (4). Born in Herkimer Co., N. Y., March 9, 1809. Died in New York, N. Y., January 10, 1861.
Hadley, George, Buffalo, N. Y. (6). Born June, 1813. Died Oct. 16, 1877.
Haldeman, Samuel Stehman, Chickies, Pa. (1). Born Aug. 12, 1812. Died Sept. 10, 1880.
Hale, Enoch, Boston, Mass. (1). Born in Westhampton, Mass., Jan. 29, 1790. Died in Boston, Mass., Nov. 12, 1848.
Hance, Ebenezer, Fallsington P. O., Pa. (7). Died in 1876.
Harding, Myron H., Lawrenceburg, Ind. (30.) Died Sept., 1885.
Hare, Robert, Philadelphia, Pa. (1). Born in Philadelphia, Pa., Jan. 17, 1781. Died in Philadelphia, May 15, 1858.
Harlan, Joseph G., Haverford, Pa. (8).
Harlan, Richard, Philadelphia, Pa. (1). Born in Philadelphia, Pa., Sept. 19, 1796. Died in New Orleans, La., Sept. 30, 1843.
Harris, Thaddeus William, Cambridge, Mass. (1). Born in Dorchester, Mass., Nov. 12, 1795. Died in Cambridge, Mass., Jan. 16, 1856.
Harrison, A. M., Plymouth, Mass. (29).
Harrison, Benjamin Franklin, Wallingford, Conn. (11). Born April 19, 1811. Died April 23, 1886.

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Harrison, Jos., jr., Philadelphia, Pa. (12). Born in Philadelphia, Pa., Sept. 20, 1810. Died in Philadelphia, March 27, 1874.

Hart, Simeon, Farmington, Conn. (1). Born Nov. 17, 1795. Died April 20, 1853.

Hartt, Charles Frederick, Ithaca, N. Y. (18). Born in Nova Scotia, Aug. 20, 1840. Died March 18, 1878.

Haven, Joseph, Chicago, Ill. (17). Born in Dennis, Mass., Jan. 4, 1816. Died May 23, 1874.

Hawes, George W., Washington, D. C. (23). Born Dec. 31, 1848. Died June 22, 1882.

Hayden, Ferdinand Vandeveer, Philadelphia, Pa. (29). Born in Westfield, Mass., Sept. 7, 1829. Died Dec. 22, 1887.

Hayden, Horace H., Baltimore, Md. (1). Born in Winsor, Conn., Oct. 13, 1769. Died in Baltimore, Md., Jan. 26, 1844.

Hayes, George E., Buffalo, N. Y. (15).

Hayward, James, Boston, Mass. (1). Born in Concord, Mass., June 12 1786. Died in Boston, Mass., July 27, 1866.

Hazen, William Babcock, Washington, D. C. (30). Born in Hartford, Vt., Sept. 27, 1830. Died Jan. 16, 1887.

Hedrick, Benjamin Sherwood, Washington, D. C. (19). Born in 1826. Died Sept. 2, 1886.

Heighway, A. E., Cincinnati, Ohio (29). Born Dec. 26, 1820. Died Jan. 24, 1888.

Hempstead, G. S. B., Portsmouth, Ohio (29). Born in 1795. Died July 9, 1883.

Henry, Joseph, Washington, D. C. (1). Born in Albany, N. Y., Dec. 17 1797. Died May 13, 1878.

Hickox, S. V. R., Chicago, Ill. (17). Died in 1872.

Hicks, William C., New York, N. Y. (34). Died in 1885.

Hilgard, Theodore Charles, St. Louis, Mo. (17). Born in Zweibrücken, Germany, Feb. 28, 1828. Died March 5, 1875.

Hill, Walter N., Chester, Pa. (29). Born Apr. 15, 1846. Died March 29, 1884.

Hincks, William, Toronto, C. W. (11). Born in 1801. Died July, 1871.

Hitchcock, Edward, Amherst, Mass. (1). Born in Deerfield, Mass., May 24, 1793. Died Feb. 27, 1864.

Hoadley, John Chipman, Boston, Mass. (29). Born Dec. 10, 1818. Died Oct. 21, 1886.

Hodgson, W. B., Savannah, Ga. (10). Born 1815.

Holbrook, John Edwards, Charleston, S. C. (1). Born in Beaufort, S. C., Dec. 30, 1796. Died in Norfolk, Mass., Sept. 8, 1871.

Holman, Mrs. S. W., Boston, Mass. (29). Died May 5, 1885.

Homes, Henry A., Albany, N. Y. (11). Born in 1812. Died Nov. 3, 1887.

Hopkins, Albert, Williamstown, Mass. (19). Born July 14, 1807. Died May 25, 1872.

Hopkins, James G., Ogdensburg, N. Y. (10). Died in 1860.

Hopkins, T. O., Williamsville, N. Y. (10). Died in 1866.

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Hopkins, Wm., Lima, N. Y. (5). Died in March, 1867.
Hoppock, Albert E., Hastings-on-Hudson, N. Y. (29).
Horton, C. V. R., Chaumont, N. Y. (10). Died in 1862.
Horton, William, Craigville, N. Y. (1).
Hosford, Benj. F., Haverhill, Mass. (13). Died in 1864.
Hough, Franklin Benjamin, Lowville, N. Y. (4). Born in Martinsville, N. Y., July 20, 1822. Died June 6, 1885.
Houghton, Douglas, Detroit, Mich. (1). Born in Troy, N. Y., Sept. 21, 1809. Died Oct. 13, 1845.
Hovey, Edmund O., Crawfordsville, Ind. (20). Born July 15, 1801. Died March 10, 1877.
Howland, Edward Perry, Washington, D. C. (29). Born in Ledyard, N. Y., July 20, 1825. Died in Harrisburg, Pa., Sept. 12, 1888.
Howland, Theodore, Buffalo, N. Y. (15).
Hubbert, James, Richmond, Province of Quebec (16). Died in 1868.
Hunt, Edward Bissell, Washington, D. C. (2). Born in Livingston Co., N. Y., June 15, 1822. Died in Brooklyn, N. Y., Oct. 2, 1863.
Hunt, Freeman, New York, N. Y. (11). Born in Quincy, Mass., March 21, 1804. Died in Brooklyn, N. Y., March 2, 1858.

Ives, Moses B., Providence, R. I. (9). Died in 1857.
Ives, Thomas P., Providence, R. I. (10).

Jackson, Charles Thomas, Boston, Mass. (1). Born in Plymouth, Mass., June 21, 1805. Died Aug. 28, 1880.
James, Thomas Potts, Cambridge, Mass. (22). Born Sept. 1, 1803. Died Feb. 22, 1882.
Johnson, Walter Rogers, Washington, D. C. (1). Born in Leominster, Mass., June 21, 1794. Died April 26, 1852.
Johnson, William Schuyler, Washington, D. C. (31). Born Sept. 20, 1859. Died Oct. 6, 1883.
Jones, Catesby A. R., Washington, D. C. (8).
Jones, Henry A., Portland, Me. (29). Died Sept. 3, 1883.
Jones, James H., Boston, Mass. (28).

Kedzie, W. K., Oberlin, Ohio (25).
Keely, George W., Waterville, Me. (1). Died in 1878.
Keep, N. C., Boston, Mass. (13). Died in March, 1875.
Kennicott, Robert, West Northfield, Ill. (12). Born Nov. 13, 1835. Died in 1866.
Kerr, Washington Caruthers, Raleigh, N. C. (10). Born May 24, 1827. Died Aug. 9, 1885.
Kidder, Henry Purkitt, Boston, Mass. (29). Born Jan. 8, 1823. Died Jan. 28, 1886.
King, Mitchell, Charleston, S. C. (3). Born in Scotland, June 8, 1783. Died Nov. 12, 1862.
Kirkpatrick, James A., Philadelphia, Pa. (7). Died June 3, 1886.

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Kite, Thomas, Cincinnati, Ohio (5). Died Feb. 6, 1884.
Klippart, John H., Columbus, Ohio (17). Died October, 1878.
Knickerbocker, Charles, Chicago, Ill. (17). Died in 1873.
Knight, J. B., Philadelphia, Pa. (21). Died March 10, 1879.

Lacklan, R., Cincinnati, Ohio (11).
Lapham, Increase Allen, Milwaukee, Wis. (3). Born in Palmyra, N. Y. March 7, 1811. Died in Oconomowoc, Wis., Sept. 14, 1875.
Larkin, Ethan Pendleton, Alfred Centre, N. Y. (33). Born Sept. 20, 1829. Died Aug. 23, 1887.
LaRoche, Réné, Philadelphia, Pa. (12). Born in Philadelphia, Pa., 1795. Died in Philadelphia, Dec., 1872.
Lasel, Edward, Williamstown, Mass. (1). Born Jan. 21, 1809. Died Jan. 31, 1852.
Lawford, Frederick, Montreal, Canada (11). Died in 1866.
Lawrence, Edward, Charlestown, Mass. (18). Born June, 1810. Died Oct. 17, 1885.
Lea, Isaac, Philadelphia, Pa. (1). Born in Wilmington, Del., March 4, 1792. Died Dec. 8, 1886.
Le Conte, John Lawrence, Philadelphia, Pa. (1). Born in New York, May 13, 1825. Died Nov. 15, 1883.
Lederer, Baron von, Washington, D. C. (1).
Lewis, Henry Carvill, Philadelphia, Pa. (26). Born in Philadelphia, Pa., Nov. 16, 1853. Died in Manchester, England, July 21, 1888.
Libbey, Joseph, Georgetown, D. C. (31). Died July 20, 1886.
Lieber, Oscar Montgomery, Columbia, S. C. (8). Born Sept. 8, 1830. Died June 27, 1862.
Lincklaen, Ledyard, Cazenovia, N. Y. (1). Died April 25, 1864.
Linsley, James Harvey, Stafford, Conn. (1). Born in Northford, Conn., May 5, 1787. Died in Stratford, Conn., Dec. 26, 1843.
Lockwood, Moses B., Providence, R. I. (9). Died in 1872.
Logan, William Edmond, Montreal, Canada (1). Born in Montreal, Canada, April 23, 1798. Died in Wales, June 22, 1875.
Loiseau, Emile F., Brussels, Belgium (33). Died April 30, 1886.
Loosey, Charles F., New York, N. Y. (12).
Lothrop, Joshua R., Buffalo, N. Y. (15).
Lowrie, J. R., Warriorsmark, Pa. (29). Died Dec. 10, 1885.
Lull, Edward Phelps, Washington, D. C. (28). Born Feb. 20, 1836. Died March 5, 1887.
Lyford, Moses, Springfield, Mass. (22). Died Aug. 4, 1887.
Lyon, Sidney S., Jeffersonville, Ind. (20). Born Aug. 4, 1808. Died June 24, 1872.

M'Conihe, Isaac, Troy, N. Y. (5).
McCutchen, A. R., Atlanta, Ga. (25). Died Nov. 21, 1887.
McFadden, Thomas, Westerville, Ohio (30). Born Nov. 9, 1825. Died Nov. 9, 1883.

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MacGregor, Donald, Houston, Texas (33). Died in Oct., 1887.
McLachlan, J. S., Montreal, Can. (31).
McMahon, Mathew, Albany, N. Y. (11).
Maack, G. A., Cambridge, Mass. (18). Died in Aug., 1873.
Macfarlane, James, Towanda, Pa. (29). Died in 1885.
Mahan, Dennis Hart, West Point, N. Y. (9). Born in New York, N. Y., April 2, 1802. Died in New York, Sept. 16, 1871.
Marler, George L., Montreal, Can. (31).
Marsh, Dexter, Greenfield, Mass. (1). Born in Montague, Mass., Aug. 22, 1806. Died in Greenfield, Mass., April 2, 1853.
Marsh, James E., Roxbury, Mass. (10).
Martin, Benjamin Nichols, New York, N. Y. (23). Born in Mount Holly, N. J., Oct. 20, 1816. Died in New York, N. Y., Dec. 26, 1883.
Mather, William Williams, Columbus, Ohio (1). Born in Brooklyn, Conn., May 24, 1804. Died in Columbus, Ohio, Feb. 27, 1859.
Maude, John B., St. Louis, Mo. (27). Died in April, 1879.
Maupin, S., Charlottesville, Va. (10).
Meade, George Gordon, Philadelphia, Pa. (15). Born Dec. 30, 1815. Died Nov. 6, 1872.
Meek, Fielding Bradford, Washington, D. C. (6). Born Dec. 10, 1817. Died Dec. 21, 1876.
Meigs, James Aitken, Philadelphia, Pa. (12). Born July 30, 1829. Died Nov. 9, 1879.
Minifie, William, Baltimore, Md. (12). Born Aug. 14, 1805. Died Oct. 24, 1880.
Mitchel, Ormsby MacKnight, Cincinnati, Ohio (3). Born in Union Co., Ky., July 28, 1810. Died in Beaufort, S. C., Oct. 30, 1862.
Mitchell, William, Poughkeepsie, N. Y. (2). Born in Nantucket, Mass., Dec. 20, 1791. Died in Poughkeepsie, N. Y., April 19, 1868.
Mitchell, Wm. H., Florence, Ala. (17).
Monroe, Nathan, Bradford, Mass. (6). Born in Minot, Me., May 16, 1804. Died in Bradford, Mass., July 8, 1866.
Monroe, William, Concord, Mass. (18). Died April 27, 1877.
Morgan, Lewis Henry, Rochester, N. Y. (10). Born near Aurora, N. Y., Nov. 21, 1818. Died Dec. 17, 1881.
Morgan, Mrs. Mary E., Rochester, N. Y. (31). Died in 1884.
Morris, John B., Nashville, Tenn. (26).
Morton, Samuel George, Philadelphia, Pa. (1). Born in Philadelphia, Pa., Jan. 26, 1799. Died in Philadelphia, May 15, 1851.
Mudge, Benjamin Franklin, Manhattan, Kansas (25). Born in Orrington, Me., Aug. 11, 1817. Died Nov. 21, 1879.
Muir, William, Montreal, Can. (31). Died July, 1885.
Mussey, William Heberdom, Cincinnati, Ohio (30). Born Sept. 30, 1818. Died Aug. 1, 1882.

Newland, John, Saratoga Springs, N. Y. (28). Died Jan. 18, 1880.
Newton, E. H., Cambridge, N. Y. (1).

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Nichols, Charles A., Providence, R. I. (17). Born Jan. 4, 1826. Died Oct. 20, 1877.

Nichols, William Ripley, Boston, Mass. (18). Born April 30, 1847. Died July 14, 1886.

Nicholson, Thomas, New Orleans, La. (21).

Nicollet, Jean Nicholas, Washington, D. C. (1). Born in Savoy, France, July 24, 1786. Died in Washington, D. C., Sept. 11, 1843.

Norton, John Pitkin, New Haven, Conn. (1). Born July 19, 1822. Died Sept. 5, 1852.

Norton, William Augustus, New Haven, Conn. (6). Born in East Bloomfield, N. Y., Oct. 25, 1810. Died Sept. 21, 1883.

Noyes, James Oscar, New Orleans, La. (21). Born in Niles, N. Y., June 14, 1829. Died in New Orleans, La., Sept. 11, 1872.

Nutt, Cyrus, Bloomington, Ind. (20). Born in Trumbull Co., Ohio, Sept. 4, 1814. Died in Bloomington, Aug. 23, 1875.

Oakes, Wm., Ipswich, Mass. (1). Born July 1, 1799. Died July 31, 1848.

Ogden, Robert W., New Orleans, La. (21). Died March 24, 1878.

Ogden, William Butler, High Bridge, N. Y. (17). Born in New York, N. Y., 1805. Died in New York, Aug. 3, 1877.

Oliver, Miss Mary E., Ithaca, N. Y. (20).

Olmsted, Alexander Fisher, New Haven, Conn. (4). Born Dec. 20, 1822. Died May 5, 1853.

Olmsted, Denison, New Haven, Conn. (1). Born in East Hartford, Conn., June 18, 1791. Died in New Haven, Conn., May 13, 1859.

Olmsted, Denison, jr., New Haven, Conn. (1). Born Feb. 16, 1824. Died Aug. 15, 1846.

Orton, James, Poughkeepsie, N. Y. (18). Born in Seneca Falls, N. Y., April 21, 1830. Died in Peru, S. A., Sept. 24, 1877.

Osbun, Isaac J., Salem, Mass. (29).

Otis, George Alexander, Washington, D. C. (10). Born in Boston, Mass., Nov. 12, 1830. Died Feb. 23, 1881.

Packer, Harry E., Mauch Chunk, Pa. (30). Died Feb. 1, 1884.

Painter, Jacob, Lima, Pa. (23). Died in 1876.

Painter, Minshall, Lima, Pa. (7).

Parker, Wilbur F., West Meriden, Conn. (23). Died in 1876.

Parkman, Samuel, Boston, Mass. (1). Born in 1816. Died Dec. 15, 1854.

Parsons, Henry Betts, New York, N. Y. (30). Born Nov. 20, 1855. Died Aug. 21, 1885.

Payn, Charles H., Saratoga Springs, N. Y. (28). Born May 16, 1814. Died Dec. 20, 1881.

Peirce, Benjamin Osgood, Beverly, Mass. (18). Born in Beverly, Sept. 26, 1812. Died in Beverly, Nov. 12, 1883.

Peirce, Benjamin, Cambridge, Mass. (1). Born in Salem, Mass., April 4, 1809. Died in Cambridge, Mass., Oct. 6, 1880.

Perch, Bernard, Frankford, Pa. (35). Born in 1850. Died in 1887.

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Perkins, George Roberts, Utica, N. Y. (1). Born in Otsego Co., N. Y., May 3, 1812. Died in New Hartford, N. Y., Aug. 22, 1876.

Perkins, Henry C., Newburyport, Mass. (18). Born Nov. 13, 1804. Died Feb. 2, 1873.

Perry, John B., Cambridge, Mass. (16). Born in 1820. Died Oct. 3, 1872.

Perry, Matthew Calbraith, New York, N. Y. (10). Born in South Kingston, R. I., 1795. Died in New York, March 4, 1858.

Phelps, Mrs. Almira Hart Lincoln, Baltimore, Md. (13). Born in Berlin, Conn., July 15, 1793. Died in Berlin, July 15, 1884.

Phillips, John C., Boston, Mass. (29). Born in 1839. Died March 1, 1885.

Piggot, A. Snowden, Baltimore, Md. (10).

Pim, Bedford Clapperton Trevelyan, London, Eng. (33). Born in England, June 12, 1826. Died Oct., 1886.

Platt, W. G., Philadelphia, Pa. (32). Died Nov., 1885.

Plumb, Ovid, Salisbury, Conn. (9).

Pope, Charles Alexander, St. Louis, Mo. (12). Born in Huntsville, Ala., March, 15, 1818. Died in Paris, Mo., July 6, 1870.

Porter, John Addison, New Haven, Conn. (14). Born in Catskill, N. Y., March 15, 1822. Died in New Haven, Conn., Aug. 25, 1866.

Potter, Stephen H., Hamilton, Ohio (30). Born Nov. 10, 1812. Died Dec. 9, 1883.

Pourtalès, Louis François de, Cambridge, Mass. (1). Born March 4, 1824. Died July 19, 1880.

Pruyn, John Van Schaick Lansing, Albany, N. Y. (1). Born in Albany, N. Y. June 22, 1811. Died in Clifton Springs, N. Y., Nov. 21, 1877.

Pugh, Evan, Centre Co., Pa. (14). Born Feb. 29, 1828. Died April 29, 1864.

Pulsifer, Sidney, Philadelphia, Pa. (21). Died March 24, 1884.

Putnam, Mrs. Frederick Ward, Cambridge, Mass. (19). Born in Charlestown, Mass., Dec. 29, 1838. Died in Cambridge, Mass., March 10, 1879.

Putnam, J. Duncan, Davenport, Iowa (27). Born Oct. 18, 1855. Died Dec. 10, 1881.

Read, Ezra, Terre Haute, Ind. (20). Died in 1877.

Redfield, William C., New York, N. Y. (1). Born near Middletown, Conn., March 26, 1789. Died Feb. 12, 1857.

Resor, Jacob, Cincinnati, Ohio (8). Died in 1871.

Robb, James, Fredericton, N. B. (4).

Robinson, Coleman T., Buffalo, N. Y. (15).

Rochester, Thomas Fortescue, Buffalo, N. Y. (35). Born Oct. 8, 1823. Died May 24, 1887.

Rockwell, John Arnold, Norwich, Conn. (10). Born in Norwich, Conn., August 27, 1803. Died in Washington, D. C., February 10, 1861.

Roeder, F. A., Cincinnati, Ohio (30).

Rogers, Henry Darwin, Glasgow, Scotland (1). Born in Philadelphia, Pa., Aug. 1, 1808. Died in Glasgow, Scotland, May 29, 1866.

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Rogers, James Blythe, Philadelphia, Pa. (1). Born in Philadelphia, Pa., Feb. 11, 1802. Died in Philadelphia, June 15, 1852.

Rogers, Robert Emple, Philadelphia, Pa. (18). Born in Baltimore, Md., March 29, 1813. Died Sept. 6, 1884.

Rogers, William Barton, Boston, Mass. (1). Born in Philadelphia, Pa., Dec. 7, 1804. Died in Philadelphia, May 30, 1882.

Root, Elihu, Amherst, Mass. (25). Born Sept. 14, 1845.

Sager, Abram, Ann Arbor, Mich. (6). Born in Bethlehem, N. Y., Dec. 22, 1811. Died August 6, 1877.

Sanders, Benjamin D., Wellsburg, W. Va. (19).

Schaeffer, Geo. C., Washington, D. C. (1). Died in 1873.

Schley, William, New York, N. Y. (28). Died in 1882.

Scott, Joseph, Dunham, C. E. (11). Died in 1865.

Seaman, Ezra Champion, Ann Arbor, Mich. (20). Born Oct. 14, 1805. Died July 15, 1880.

Senter, Harvey S., Aledo, Ill. (20). Died in 1875.

Seward, William Henry, Auburn, N. Y. (1). Born in Florida, N. Y., May 16, 1801. Died in Auburn, N. Y., Oct. 10, 1872.

Sheppard, William, Drummondville, Province of Quebec, Can. (11). Born in 1783. Died in 1867.

Sherwin, Thomas, Dedham, Mass. (11). Born in Westmoreland, N. H., March 26, 1799. Died in Dedham, Mass., July 23, 1869.

Sill, Elisha N., Cuyahoga Falls, Ohio (6). Born in 1801. Died April 26, 1888.

Silliman, Benjamin, New Haven, Conn. (1). Born in North Stratford, Conn., August 8, 1779. Died in New Haven, Conn., Nov. 22, 1864.

Silliman, Benjamin, New Haven, Conn. (1). Born in New Haven, Conn., Dec. 4, 1816. Died Jan. 14, 1885.

Skinner, John B., Buffalo, N. Y. (15). Died in 1871.

Slack, J. H., Philadelphia, Pa. (12).

Smith, Charles A., St. Louis, Mo. (27). Died in 1884.

Smith, David P., Springfield, Mass. (29). Born Oct. 1, 1830. Died Dec. 26, 1880.

Smith, Mrs. Erminnie Adelle, Jersey City, N. J. (25). Born April 26, 1836. Died June 9, 1886.

Smith, John Lawrence, Louisville, Ky. (1). Born near Charleston, S. C., Dec. 17, 1818. Died Oct. 12, 1883.

Smith, J. V., Cincinnati, Ohio (5).

Smith, James Young, Providence, R. I. (9). Born in Groton, Conn., Sept. 15, 1809. Died March 26, 1876.

Smith, Lyndon Arnold, Newark, N. J. (9). Born in Haverhill, N. H., November 11, 1795. Died in Newark, N. J., December 15, 1865.

Snell, Ebenezer Strong, Amherst, Mass. (2). Born in North Brookfield, Mass., October 7, 1801. Died in Amherst, Mass., Sept., 1877.

Sparks, Jared, Cambridge, Mass. (2). Born in Willington, Conn., May 10, 1819. Died in Cambridge, Mass., March 14, 1866.

Spinzig, Charles, St. Louis, Mo. (27). Died Jan. 22, 1882.

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Squier, Ephraim George, New York, N. Y. (18). Born in Bethlehem, N. Y., June 17, 1821. Died in Brooklyn, N. Y., April 17, 1888.

Stearns, Josiah A., Boston, Mass. (29).

Stearns, Silas, Pensacola, Fla. (28). Died Aug. 2, 1888.

Steele, Joel Dorman, Elmira, N. Y. (33). Born in Luna, N. Y., May 14, 1836. Died May 25, 1886.

Stevenson, James, Washington, D. C. (29). Born Dec. 24, 1840. Died July 23, 1888.

Stimpson, William, Chicago, Ill. (12). Born Feb. 14, 1832. Died May 26, 1872.

Stone, Leander, Chicago, Ill. (32). Died April 2, 1888.

Stone, Samuel, Chicago, Ill. (17). Born Dec. 6, 1798. Died May 4, 1876.

St. John, Joseph S., Albany, N. Y. (28). Died Nov. 23, 1882.

Straight, H. H., Chicago, Ill. (25). Died Nov. 17, 1886.

Sullivan, Algernon Sidney, New York, N. Y. (36). Born April 5, 1826. Died Dec. 4, 1887.

Sullivant, William Starling, Columbus, Ohio (7). Born near Columbus, O., Jan 15, 1803. Died in Columbus, O., April 30, 1873.

Sutton, George, Aurora, Ind. (20.) Died June 13, 1886.

Swain, James, Fort Dodge, Iowa (21). Born in 1816. Died in 1877.

Tallmadge, James, New York, N. Y. (1). Born in Stamford, N. Y., Jan. 20, 1778. Died in New York, N. Y., Oct. 3, 1853.

Taylor, Arthur F., Cleveland, Ohio (29). Born Dec. 10, 1853. Died June 28, 1883.

Taylor, Richard Cowling, Philadelphia, Pa. (1). Born in England, Jan. 18, 1789. Died in Philadelphia, Pa., November 26, 1851.

Taylor, Robert N., Tollesboro, Ky. (37). Died Aug. 13, 1888.

Tenney, Sanborn, Williamstown, Mass. (17). Born in January, 1827. Died July 11, 1877.

Teschemacher, James Englehert, Boston, Mass. (1). Born in Nottingham, England, June 11, 1790. Died near Boston, Nov. 9, 1853.

Thompson, A. Remsen, New York, N. Y. (1). Died in Oct., 1879.

Thompson, Alexander, Aurora, N. Y. (1).

Thompson, Charles Oliver, Terre Haute, Ind. (29). Born in East Windsor Hill, Conn., Sept. 25, 1835. Died in Terre Haute, Ind., March 17, 1885.

Thompson, Zadock, Burlington, Vt. (1). Born in Bridgewater, Vt., May 23, 1796. Died in Burlington, Vt., Jan 19, 1856.

Thomson, Henry R., Crawfordsville, Ind. (30). Died in 1884.

Thurber, Isaac, Providence, R. I. (9).

Tillman, Samuel Dyer, Jersey City, N. J. (15). Born April, 1815. Died Sept. 4, 1875.

Tobin, Thomas W., Louisville, Ky. (30). Died Aug. 4, 1888.

Todd, Albert, St. Louis, Mo. (27). Born March 4, 1813. Died April 30, 1885.

Tolderoy, James B., Fredericton, N. B. (11).

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Torrey, John, New York, N. Y. (1). Born in New York, N. Y., Aug. 15, 1796. Died in New York, March 10, 1873.

Torrey, Joseph, Burlington, Vt. (2). Born in Rowley, Mass., Feb. 2, 1797. Died in Burlington, Vt., Nov. 26, 1867.

Totten, Joseph Gilbert, Washington, D. C. (1). Born in New Haven, Conn., August 23, 1788. Died in Washington, D. C., April 22, 1864.

Townsend, Howard, Albany, N. Y. (10). Born Nov. 22, 1823. Died Jan. 6, 1867.

Townsend, John Kirk, Philadelphia, Pa. (1). Born Aug. 10, 1809. Died Feb. 16, 1851.

Townsend, Robert, Albany, N. Y. (9). Born 1799. Died Aug. 15, 1866.

Troost, Gerard, Nashville, Tenn. (1). Born in Bois-le-Duc, Holland, March 15, 1776. Died in Nashville, Tenn., Aug. 14, 1850.

Tuomey, Michael, Tuscaloosa, Ala. (1). Born in Ireland, September 29, 1805. Died in Tuscaloosa, Ala., March 20, 1857.

Tyler, Edward R., New Haven, Conn. (1). Born Aug. 8, 1800. Died Sept. 28, 1848.

Vancleve, John W., Dayton, Ohio (1).

Vanuxem, Lardner, Bristol, Pa. (1). Born in Philadelphia, Pa., July 23, 1792. Died in Bristol, Pa., June 25, 1848.

Vaux, William Sanson, Philadelphia, Pa. (1). Born in Philadelphia, May 19, 1811. Died in Philadelphia, May 5, 1882.

Wadsworth, James Samuel, Genesee, N. Y. (2). Born in Geneseo, N. Y., October 30, 1807. Died near Chancellorville, Va., May 8, 1864.

Wagner, Tobias, Philadelphia, Pa. (9).

Walker, J. R., Bay Saint Louis, Miss. (19). Born Aug. 7, 1830. Died June 22, 1887.

Walker, Joseph, Oxford, N. Y. (10).

Walker, Sears C., Washington, D. C. (1). Born March 28, 1805. Died January 30, 1853.

Walker, Timothy, Cincinnati, Ohio (4). Born in Wilmington, Mass., Dec. 1, 1802. Died in Cincinnati, Ohio, Jan. 15, 1856.

Walling, H. F., Cambridge, Mass. (16). Died April 8, 1888.

Walsh, Benjamin D., Rock Island, Ill. (17).

Wanzer, Ira, Brookfield, Conn. (18). Born April 17, 1796. Died March 5, 1879.

Warnecke, Carl, Montreal, Can. (31). Died May 14, 1886.

Warren, Geo. Washington, Boston, Mass. (18). Died in 1884.

Warren, Gouverneur Kemble, Newport, R. I. (12). Born in Cold Spring N. Y., Jan. 8, 1830. Died in Newport, R. I., Aug. 8, 1882.

Warren, John Collins, Boston, Mass. (1). Born in Boston, Mass., Aug. 1, 1778. Died in Boston, May 4; 1856.

Warren, Samuel D., Boston, Mass. (29). Born in 1817. Died May 11, 1888.

Watertown, Charles, Wakefield, Eng. (1). Born in Wakefield, Eugland. Died in Wakefield, May 26, 1865.

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Watkins, Samuel, Nashville, Tenn. (26).

Watson, James Craig, Ann Arbor, Mich. (13). Born in Fingal, Canada, Jan. 28, 1838. Died in Madison, Wis., Nov. 23, 1880.

Webster, Horace B., Albany, N. Y. (1). Born in 1812. Died Dec. 8, 1843.

Webster, J. W., Cambridge, Mass. (1). Born in 1793. Died Aug. 30, 1850.

Webster, M. H., Albany, N. Y. (1).

Weed, Monroe, Wyoming, N. Y. (6). Died in 1867.

Welch, Mrs. G. O., Lynn, Mass. (21). Died in June, 1882.

Welsh, John, Philadelphia, Pa. (33). Died May, 1886.

Weyman, George W., Pittsburgh, Pa. (6). Born April, 1832. Died July 16, 1864.

Wheatland, Richard H., Salem, Mass. (13). Born July 6, 1830. Died Dec. 21, 1868.

Wheatley, Charles M., Phœnixville, Pa. (1). Died May 6, 1882.

Wheeler, Arthur W., Baltimore, Md. (29). Born in March, 1859. Died Jan. 6, 1881.

Whitall, Henry, Camden, N. J. (33).

White, Samuel S., Philadelphia, Pa. (23). Died Dec. 30, 1879.

Whiting, Lewis E., Saratoga Springs, N. Y. (28). Born March 7, 1815. Died Aug. 2, 1882.

Whitman, Edmund B., Cambridge, Mass. (29). Died Sept. 2, 1883.

Whitman, Wm. E., Philadelphia, Pa. (23). Died in 1875.

Whitney, Asa, Philadelphia, Pa. (1). Born Dec. 1, 1791. Died June 4, 1874.

Whittlesey, Charles, Cleveland, Ohio (1). Born in Southington, Conn., Oct. 5, 1808. Died Oct. 18, 1886.

Whittlesey, Charles C., St. Louis, Mo. (11). Died in 1872.

Wilder, Graham, Louisville, Ky. (30). Born July 1, 1843. Died Jan. 16, 1885.

Willard, Emma C. Hart, Troy, N. Y. (15). Born in Berlin, Conn., Feb. 23, 1787. Died in Troy, N. Y., April 15, 1870.

Williams, Frank, Buffalo, N. Y. (25). Died Aug. 13, 1884.

Williams, P. O., Watertown, N. Y. (24).

Williamson, Robert S., San Francisco, Cal. (12). Born in New York about 1825.

Wilson, W. C., Carlisle, Pa. (12).

Winlock, Joseph, Cambridge, Mass. (5). Born in Shelbyville, Ky., Feb. 6, 1826. Died in Cambridge, Mass., June 11, 1875.

Woodbury, Levi, Portsmouth, N. H. (1). Born in Francistown, N. H., Dec. 22, 1789. Died Sept. 4, 1851.

Woodman, John Smith, Hanover, N. H. (11). Born in Durham, N. H., Sept. 6, 1819. Died in Durham, N. H., May 15, 1871.

Woodward, Joseph Janvier, Washington, D. C. (28). Born in Philadelphia, Pa., Oct. 30, 1833. Died near that city, Aug. 17, 1884.

Worthen, Amos Henry, Springfield, Ill. (5). Born Oct. 31, 1813. Died May 6, 1888.

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Wright, Elizur, Boston, Mass. (31). Born in South Canaan, Conn., Feb. 12, 1804. Died Nov. 20, 1885.

Wright, Harrison, Wilkes Barre, Pa. (29). Born July 15, 1850. Died Feb. 20, 1885.

Wright, John, Troy, N. Y. (1).

Wyman, Jeffries, Cambridge, Mass. (1). Born in Chelmsford, Mass., Aug. 11, 1814. Died in Bethelem, N. H., Sept. 4, 1874.

Wyckoff, William Cornelius, New York, N. Y. (20). Born in New York, N. Y., May 28, 1832. Died in Brooklyn, N. Y., May 2, 1888.

Yarnall, M., Washington, D. C. (26). Born in 1817. Died Jan. 27, 1879.

Youmans, Edward Livingston, New York, N. Y. (6). Born in Coeymans, N. Y., June 3, 1821. Died Jan. 18, 1887.

Young, Ira, Hanover, N. H. (1). Born in Lebanon, N. H., May 23, 1801. Died in Hanover, N. H., Sept. 14, 1858.

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BOSTON MEDICAL LIBRARY ASS'N.
JUL 18 1892

ADDRESS

BY

S. P. LANGLEY,

THE RETIRING PRESIDENT OF THE ASSOCIATION.

THE HISTORY OF A DOCTRINE.

"Man, being the servant and interpreter of nature, can do and understand so much, and so much only, as he has observed, in fact or in thought, of the course of nature. Beyond this he neither knows anything nor can do anything."—BACON'S *Novum Organum*, aphorism I.

IN these days, when a man can take but a very little portion of knowledge to be his province, it has become customary that your president's address shall deal with some limited topic, with which his own labors have made him familiar; and accordingly I have selected as my theme, the history of our present views about radiant energy, not only because of the intrinsic importance of the subject, but because the study of this energy in the form of radiant heat is one to which I have given special attention.

Just as the observing youth, who leaves his own household to look abroad for himself, comes back with the report that the world, after all, is very like his own family, so may the specialist, when he looks out from his own department, be surprised to find that, after all, the history of the narrowest specialty is strangely like that of scientific doctrine in general, and contains the same lessons for us. To find some of the most useful ones, it is important, however, to look with our own eyes at the very words of the masters themselves, and to take down the dusty copy of Newton, or Boyle, or Leslie, instead of a modern abstract; for, strange as it may seem, there is something of great moment in the original that has never yet been incorporated into any encyclopædia, something really es-

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sential in the words of the man himself which has not been indexed in any text-book, and never will be.

It is not for us, then, here to-day, to try

> "How index-learning turns no student pale,
> Yet holds the eel of science by the tail;"

but, on the contrary, to remark that from this index-learning, from these histories of science and summaries of its progress, we are apt to get wrong ideas of the very conditions on which this progress depends. We often hear it, for instance, likened to the march of an army toward some definite end; but this, it has seemed to me, is not the way science usually does move, but only the way it seems to move in the retrospective view of the compiler, who probably knows almost nothing of the real confusion, diversity, and retrograde motion of the individuals comprising the body, and only shows us such parts of it as he, looking backward from his present standpoint, now sees to have been in the right direction.

I believe this comparison of the progress of science to that of an army, which obeys an impulse from one head, has more error than truth in it; and, though all similes are more or less misleading, I would prefer to ask you to think rather of a moving crowd, where the direction of the whole comes somehow from the independent impulses of its individual members; not wholly unlike a pack of hounds, which, in the long-run, perhaps catches its game, but where, nevertheless, when at fault, each individual goes his own way, by scent, not by sight, some running back and some forward; where the louder-voiced bring many to follow them, nearly as often in a wrong path as in a right one; where the entire pack even has been known to move off bodily on a false scent;—for this, if a less dignified illustration, would be one which had the merit of having a truth in it, left out of sight by the writers of text-books.

At any rate, the actual movement has been tortuous, or often even retrograde, to a degree of which you will get no idea from the account in the text-book or encyclopædia, where, in the main, only the resultant of all these vacillating motions is given. With rare exceptions, the backward steps—that is, the errors and mistakes, which count in reality for nearly half, and sometimes for more than half, the whole—are left out of scientific history; and the reader, while he knows that mistakes have been made, has no just idea how intimately error and truth are mingled in a sort of chemical union, even in the work of the great discoverers, and how

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it is the test of time chiefly,— which enables us to say which *is* progress, when the man himself could not. If this be a truism, it is one which is often forgotten, and which we shall do well to here keep before us.

This is not the occasion to review the vague speculations of the ancient natural philosophers from Aristotle to Zeno, or to give the opinion of the schoolmen on our subject. We take it up with the immediate predecessors of Newton, among whom we may have been prepared to expect some obscure recognition of heat as a mode of motion, but where it has been, to me at least, surprising, on consulting their original works, to find how general and how clear an anticipation of our modern doctrine may be fairly said to exist. Whether this early recognition be a legacy from the Lucretian philosophy, it is not necessary to here consider. The interesting fact, however it came about, is the extent to which seventeenth-century thought is found to be occupied with views which we are apt to think very recent.

Descartes, in 1664, commences his "Le Monde" by a treatise on the propagation of light, and what we should now call radiant heat by vibrations, and further associates this view of heat as motion with the distinct additional conception, that in the cause of light and radiant heat we may expect to find something quite different from the sense of vision or of warmth; and he expresses himself with the aid of the same simile of sound employed by Draper over two hundred years later. The writings of Boyle on the mechanical production of heat contain illustrations (like that of the hammer driving the nail, which grows hot in proportion as its bodily motion is arrested) which show a singularly complete apprehension of views we are apt to think we have made our own; and it seems to me that any one who consults the originals will admit, that, though its full consequences have not been wrought out till our own time, yet the fundamental idea of heat as a mode of motion is so far from being a modern one, that it was announced in varying forms by Newton's immediate predecessors, by Descartes, by Bacon, by Hobbes, and in particular by Boyle, while Hooke and Huyghens merely continue their work, as at first does Newton himself.

If, however, Newton found the doctrine of vibrations already, so to speak, "in the air," we must, while recognizing that in the

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history of thought the new always has its root in the old, and that it is not given even to a Newton to create an absolutely new light, still admit that the full dawn of our subject properly begins with him, and admit, too, that it is a bright one, when we read in the "Optics" such passages as these:—

"Do not all fixed bodies, when heated beyond a certain degree, emit light and shine, and is not this emission performed by the vibrating motions of their parts?" And again: Do not several sorts of rays make vibrations of several bignesses?" And still again: "Is not the heat conveyed by the vibrations of a much subtler medium than air?"

Here is the undulatory theory; here is the connection of the ethereal vibrations with those of the material solid; here is "heat as a mode of motion;" here is the identity of radiant heat and light; here is the idea of wave-lengths. What a step forward this first one is! And the second?

The second is, as we know, backward. The second is the rejection of this, and the adoption of the corpuscular hypothesis, with which alone the name of Newton (a father of the undulatory theory) is, in the minds of most, associated to-day.

Do not let us forget, however, that it was on the balancing of arguments from the facts then known, that he decided, and that perhaps it was rather an evidence of his superiority to Huyghens, that apprehending equally clearly with the latter, the undulatory theory, he recognized also more clearly that this theory, as then understood, utterly failed to account for several of the most important phenomena. With an equally judicial mind, Huyghens would perhaps have decided so too, in the face of difficulties, all of which have not been cleared up even to-day. These two great men, then, each looked around in the then darkness as far as his light carried him. All beyond that was chance to each; and fate willed that Newton, whose light shone farther than his rival's, found it extend just far enough to show the entrance to the wrong way. He reaches the conclusion that we all know; one not only wrong in regard to light, but which bears pernicious results on the whole theory of heat, since light being conceded to be material, radiant heat, if affiliated to light, must be regarded as material too, and Newton's influence is so permanent, that we shall see this strange conclusion drawn by the contemporaries of Herschel from his experiments made a hundred years later.

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It would seem then that the result of this unhappy corpuscular theory was more far-reaching than we commonly suppose, and that it is hardly too much to say that the whole promising movement of that age toward the true doctrine of radiant energy is not only arrested by it, but turned the other way; so that in this respect the philosophy of fifty years later is actually farther from the truth than that of Newton's predecessors, and the immense repute of Newton as a leader, on the whole so rightly earned, here leads astray others than his conscious disciples, and, it seems to me, affects men's opinions on topics which appear at first far removed from those he discussed. The adoption of phlogiston was, as we may reasonably infer, facilitated by it, and remotely Newton is perhaps also responsible in part for the doctrine of caloric a hundred years later. After him, at any rate, there is a great backward movement. We have a distinct retrogression from the ideas of Bacon and Hobbes and Boyle. Night settles in again on our subject almost as thick as in the days of the schoolmen, and there seems to be hardly an important contribution to our knowledge, in the first part of the eighteenth century, due to a physicist.

"Physics, beware of metaphysics," said Newton,—words which physicists are apt so exclusively to quote, that it seems only due to candor to observe that the most important step, perhaps, in the fifty years which followed the "Optics," came from Berkeley, who, reasoning as a metaphysician, gave us during Newton's lifetime a conception wonderfully in advance of his age. Yet the "New Theory of Vision" was generally viewed by contemporary philosophers as only an amusing paradox, while "coxcombs vanquish[ed] Berkeley with a grin;" and this contribution to science,—an exceptional if not a unique instance of a great physical generalization reached by *a priori* reasoning,—though published in 1709, remains in advance of the popular knowledge even in these closing years of the nineteenth century.

In the meantime a new error had risen among men,—a new truth, as it seemed to them,—and a thing destined to have a strong reflex action on the doctrine of radiant energy. It began with the generalization of a large class of phenomena which we now associate with the action of oxygen, then of course unknown, a generalization useful in itself, and accompanied by an explanation which was not in its origin objectionable. Let us consider, in illustration,

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any familiar instance of oxidation, and try to look first for what was reasonable in the eighteenth-century views of the cause of such phenomena.

A piece of dry wood has in it the power of giving out heat and light when set on fire; but after it is consumed there is left of it only inert ashes, which can give neither. Something, then, has left the wood in process of becoming ashes; virtue has gone out of it, or, as we should say, its potential energy has gone.

This is, so far, an important observation, extending over a wide range of phenomena, and, if it had presented itself to the predecessors of Newton, it would probably have been allied to the vibratory theories, and become proportionately fruitful. But to his disciples, and to chemists and others, who, without being perhaps disciples, were like all then, more or less consciously influenced by the materiality of the corpuscular theory, it appeared that this virtue also was a material emanation;— that this energy was an actual ingredient of the wood,— a crudeness of conception which seems most strange to us, but is not perhaps unaccountable in view of the then current thought.

I have said that the progress of science is not so much that of an army as of a crowd of searchers, and that a call in a false direction may be responded to, not by one only, but by the whole body. In illustration, observe that during the greater part of the entire eighteenth century, this doctrine was adopted by almost every chemist and by many physicists. It had as general an acceptance among chemists then as the kinetic theory of gases, for instance, has among physicists now, and, so far as time is any test of truth, it was tested more severely than the kinetic theory has yet been; for it was not only the lamp and guide of chemists, and to a great extent of physicists also, but it remained the time-honored and highest generalization of chemical science for over half a century, and it was accepted not so much as a conditional hypothesis, as a final guide, and a conquest for truth which should endure always. And now where is it? Dissipated so utterly from men's minds, that, to the unprofessional part of even an educated audience like this, "phlogiston," once a name to conjure with, has become an unmeaning sound.

There is no need to insist on the application of the obvious moral to hypotheses of our own day.

I have tried to recall for a moment all that "phlogiston" meant

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a little more than a hundred years ago, partly because it seems to me, that, though a chemical conception, physics is not blameless for it, but chiefly because before it quitted the world it appears to have returned to physics the wrong in a multiplied form, by generating an offspring specially inimical to true ideas about radiant heat, and which is represented by a yet familiar term. I mean "caloric."

This word is still used loosely as a synonyme for heat, but has quite ceased to be the very definite and technical term it once was. To me it has been new to find that this so familiar word "caloric," so far as my limited search has gone, was apparently coined only toward the last quarter of the last century. It is not to be found in the earliest edition of Johnston's dictionary, and, as far as I can learn, appears first in the corresponding French form in the works of Fourcroy. It expressed an idea which was the natural sequence of the phlogiston theory, and which is another illustration that the evil which such theories do lives after them.

"Caloric" first seemingly appears, then, as a word coined by the French chemists, and meant originally to signify the unknown cause of the sensation heat, without any implication as to its nature. But words, we know, though but wise men's counters, are the money of fools; and this one very soon came to commit its users to an idea which was more likely to have had its origin in the mind of a chemist at that time than of any other,—the idea of the cause of heat as a material ingredient of the hot body; something not, it is true, having weight, but which it would have been only a slight extension of the conception, to think might one day be isolated by a higher chemical art, and exhibited in a tangible form.

We may desire to recognize the perverted truth which usually underlies error and gives it currency, and be willing to believe that even "caloric" may have had some justification for its existence; but this error certainly seems to have been almost altogether pernicious for nearly the next eighty years, and down even to our own time. With this conception as a guide to the philosophers of the last years of the eighteenth century, it is not, at any rate, surprising if we find that at the end of a hundred years from Newton the crowd seems to be still going constantly farther and farther away from its true goal.

The doctrine of caloric is, however, always recognized as an hypothesis more acceptable to chemists than to physicists, some of

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whom still stand out for the theories of Newton's predecessors, even through the darkest years; so that the old idea of heat, as a mode of motion, has by no means so utterly died that it does not appear here and there during the last century, and indeed, not only among philosophers, but even in a popular form.

In an old English translation of Father Regnault's compilation on physics, dated about 1730, I find, for instance, the most explicit statement of the doctrine of heat as a mode of motion. Here heat is defined (with the aid of a simile due, I believe, to Boyle) as "any Agitation whatever of the insensible parts. Thus a Nail which is drove into the Wood by the stroke of a Hammer does not appear to be hot, because its immediate parts have but one common Movement. But should the Nail cease to drive, it would acquire a sensible Heat, because its insensible Parts which receive the Motion of the Hammer now acquire an agitation every way rapid." We certainly must admit that the user of this illustration had just and clear ideas; and the interesting point here appears to be, that as Father Regnault's was not an original work, but a mere compendium or popular scientific treatise of the period, we see, if only from this instance, that the doctrine of heat as a mode of motion was not confined to the great men of an earlier or a later time, but formed a part of the common pabulum during the eighteenth century to an extent that has been forgotten.

Although Prevost gave us his most material contribution about 1790, we have, it seems to me, on the whole, little to interest us during that barren time in the history of radiant energy called the eighteenth century,— a century in which science wore the pedant's cap and gown, and her students read the poem of Creation like grammarians, for its syntax;— a century whose latter years are given up, till near its very close, to bad *a priori* theories in our subject, except in the work of two Americans; for in the general dearth at this time of experiments in radiant heat, it is a pleasure to fancy Benjamin Franklin sitting down before the fire, with a white stocking on one leg and a black one on the other, to see which leg would burn first, and to recall again how Benjamin Thompson (Count Rumford) not only weighed "caloric" literally in the balance and found it wanting, but made that memorable experiment in the Munich founderies which showed that heat was perpetually and without limit created from motion.

It was in the last years of the century, too, that he provided for

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the medal called by his name, and which, though to be given for researches in heat and light, has, I believe, been allotted in nearly every instance to men, who, like Leslie, Malus, Davy, Brewster, Fresnel, Melloni, Faraday, Arago, Stokes, Maxwell, and Tyndall, have contributed toward the subject of radiant energy in particular.

We observe that before this time the scientific literature of the century scarcely considers the idea even of radiant heat, still less of radiant energy, so that we have been obliged here to discuss the views of its physicists about heat in general, heat and light in most minds being then distinct entities; all the ways for pilgrims to this special shrine of truth being barred, like those in Bunyan's Pilgrim's Progress, by the two unfriendly giants who are here called Phlogiston and Caloric, so that there are few scientific pilgrims who do not pay them toll.

The last years of this century were destined to see the most remarkable experiments in heat made in the whole of the hundred; for the memoir of Rumford appeared in the Philosophical Transactions for 1798; and in the very year 1800 appeared in the same place Sir William Herschel's paper, in which he describes how he placed a thermometer in successive colors of the solar spectrum, finding the heat increase progressively from the violet to the red, and increase yet more beyond the red where there was no color or light whatever; so that there are, he observes, invisible rays as well as visible. More than that, the first outnumber the second; and these dark rays are found in the very source and fount of light itself. These dark rays can also be obtained, he observes, from a candle or a piece of non-luminous hot iron, and, what is very significant, they are found to pass through glass, and to be refracted by it like luminous ones.

And now Herschel, searching for the final verity through a series of excellent experiments, asks a question which shows that he has truth, so to speak, in his hands,— he asks himself the great question whether heat and light be occasioned by the same or different rays.

Remember the importance of this (which the querist himself fully recognized); remember, that, after long hunting in the blindfold search, he has laid hands, as we now know, on the truth herself, and then see him — let go. He decides that heat and light are not occasioned by the same rays, and we seem to see the fugi-

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tive escape from his grasp, not to be again fairly caught till the next generation.

I hardly know more remarkable papers than these of Herschel's in the Philosophical Transactions for 1800, or anything more instructive in little men's successes than in this great man's failure, which came in the moment of success. I would strongly recommend the reading of these remarkable original memoirs to any physicist who knows them only at second-hand.

One more significant lesson remains, in the effect of this on the minds of his contemporaries. Herschel's observation is to us almost a demonstration of the identity of radiant heat and light; but now, though the nineteenth century is opening, it is with the doctrine in the minds of most physicists, and perhaps of all chemists, that heat is occasioned by a certain material fluid. Phlogiston is by this time dead or dying, but Caloric is very much alive, and never more perniciously active than now, when, for instance, years after Herschel's observation, we find this cited as "demonstrating the existence of caloric;"— which was, it seems, the way it looked to a contemporary.

In the year 1804 appeared what should be a very notable book in the history of our subject, written by Sir John Leslie, whose name survives perhaps in the minds of many students chiefly in connection with the "cube" which is still called after him.

Leslie, however, ought to be remembered as a man of original genius, worthy to be mentioned with Herschel and Melloni; and his, too, is one of the books which the student may be recommended to read, at least in part, in the original; not so much for the writer's instructive experiments (which will be found in our text-books) as for his most instructive mistakes, which the text-book will probably not mention.

He began by introducing the use of the simple instrument which bears his name, and a new and more delicate heat-measurer (the differential thermometer); and with these, and concave reflectors of glass and metal, he commenced experiments in radiant heat, than which, he tells us, no part of physical science then appeared so dark, so dubious, and so neglected. It is interesting, and it marks the degree of neglect he alludes to, that his first discovery was that different substances have different radiating and absorbing powers. It gives us a vivid idea of the density of previous ignorance, that it was left to the present century to demonstrate

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this elementary fact, and that Leslie, in view of such discoveries, says, "I was transported at the prospect of a new world emerging to view."

Next he shows that the radiating and absorbing powers are proportional, next that cold as well as heat seems to be radiated, and next undertakes to see whether this radiant heat has any affinity to light. He then experiments in the ability of radiant heat to pass through a transparent glass, which transmits light freely, and thinks he finds that none does pass. Radiant heat with him seems to mean heat from non-luminous sources; and the ability or non-ability of this to pass through glass, is to Leslie and his successors a most crucial test, and its failure to do so a proof that this heat is not affiliated to light.

Let us pause a moment here to reflect that we are apt to unconsciously assume, while judging from our own present standpoint where past error is so plain, that the false conclusion can only be chosen by an able, earnest, conscientious seeker, after a sort of struggle. Not so. Such a man is found welcoming the false with rapture, as very truth herself.

"What, then," says Leslie, "is this calorific and frigorific fluid after which we are inquiring? It is not light, it has no relation to ether, it bears no analogy to the fluids, real or imaginary, of magnetism and electricity. But why have recourse to invisible agents? *Quod petis, hic est.* It is merely the ambient AIR."

The capitals are Leslie's own, but ere we smile with superior knowledge, let us put ourselves in his place, and then we may comprehend the exultation with which he announces the identity of radiant heat and common air, for he feels that he is beginning a daring revolt against the orthodox doctrine of caloric; and so he is.

The first five years of this century are notable in the history of radiant energy, not only for the work of Leslie, and for the observation by Wollaston, Ritter, and others, of the so-called "chemical" rays beyond the violet, but for the appearance of Young's papers, reëstablishing the undulatory theory, which he indeed considered in regard to light, but which was obviously destined to affect most powerfully the theory of radiant energy in general.

We are now in the year 1804, or over a century and a quarter since the corpuscular theory was emitted, and during that time it has gradually grown to be an article of faith in a sort of scientific church, where Newton has come to be looked on as an infallible

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head, and his views as dogmas, about which no doubt is to be tolerated; but if we could go back to Cambridge in the year 1668, when the obscure young student, in no way conscious of his future pontificate, takes his degree (standing twenty-third on the list of graduates), we should probably find that he had already elaborated and greatly improved certain already current ideas into the undulatory theory of light, which he at any rate promulgated a few years later, and afterward, pressed with many difficulties, altered, as we now know, to an emissive one.

Probably, if we could have heard his own statement then, he would have told how sorely tried he was between these two opinions, and, while explaining to us how the wavering balance came to lean as it did, would have admitted, with the modesty proper to such a man, that there was a great deal to be said on either side. We may, at any rate, be sure that it would not be from the lips of Newton himself that we should have had this announced as a belief which was to be part of the rule of faith to any man of science.

But observe how, if science and theology look askance at each other, it is still true that some scientific men and some theologians have, at any rate, more in common than either is ready to admit; for at the beginning of this century Newton's followers, far less tolerant than their master, have made out of this modest man a scientific pontiff, and out of his diffident opinions a positive dogma, till as years go on, he comes to be cited as so infallible that a questioning of these opinions is an offence deserving excommunication.

This has grown to be the state of things in 1804, when Young, a man possessing something of Newton's own greatness, ventures to put forward some considerations to show that the undulatory theory may be the true one, after all. But the prevalent and orthodox scientific faith was still that of the material nature of light; the undulatory hypothesis was a heresy, and Young a heretic. If his great researches had been reviewed by a physicist or a brother worker, who had himself trodden the difficult path of discovery, he might have been treated at least intelligently; but then, as always, the camp-followers, who had never been at the front, shouted from a safe position in the rear to the man in the dust of the fight, that he was not proceeding according to the approved rules of tactics; then, as always, these men stood between the public and the investigator, and distributed praise or blame.

If you wish to hear how the scientific heretic should be rebuked

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for his folly, listen to one who never made an observation, but, having a smattering of everything books could teach about every branch of knowledge, was judged by himself and by the public to be the fittest interpreter to it, of the physical science of this day. I mean Henry Brougham, the universal critic, the future Lord-chancellor of England, of whom it was observed, that, "if he had but known a little *law*, he would have known a little of everything." He uses the then all-powerful *Edinburgh Review* for his pulpit, and from it fulminates the condemnations of the church on the innovating memoir of the heretical Young.

"This paper," he says, "contains nothing which deserves the name of experiment or discovery; and it is, in fact, destitute of every species of merit . . . first is another lecture, containing more fancies, more blunders, more unfounded hypotheses, more gratuitous fictions . . . and all from the fertile yet fruitless brain of the eternal Dr. Young. In our second number we exposed the absurdity of this writer's 'law of interference,' as it pleases him to call one of the most incomprehensible suppositions that we remember to have met with in the history of human hypotheses."

There are whole pages of it, but this is enough; and I cite this passage among many such at command, not only as an example of the way the undulatory theory was treated at the beginning of this century in the first critical journal of Europe, but as another example of the general rule that the same thing may appear intrinsically absurd, or intrinsically reasonable, according to the year of grace in which we hear of it. The great majority, even of students of science, must take their opinions ready-made as to science in general; each knowing, so far as he can be said to know anything at first-hand, only that little corner which research has made specially his own.

The moral we can all draw, I think, for ourselves.

In spite of such criticism as this, the undulatory hypothesis of light made rapid way, and carried with it, one would now say, the necessary inference that radiant heat was due to undulations also. This was, however, no legitimate inference to those to whom radiant heat was still a fluid; and yet, in spite of all, the modern doctrine now begins to make visible progress.

A marked step is taken about 1811 by a young Frenchman, De la Roche, who deserves to be better remembered than he is, for he clearly anticipated some of Melloni's discoveries. De la Roche in

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particular shows that of two successive screens the second absorbs heat in a less ratio than the first; whence he, before any one else, I believe, derives the just and most important, as well as the then most novel conception, that radiant heat is of different *kinds*. He sees also, that, as a body is heated more and more, there is a gradual and continual advance not only in the amount of heat it sends out, but in the kind, so that, as the temperature still rises, the radiant heat becomes light by imperceptible gradations; and he concludes that heat and light are due to one simple agent, which, as the temperature rises yet more, appears more and more as light, or which, as the luminous radiation is absorbed, re-appears as heat. Very little of it, he observes, passes even transparent screens at low temperatures, but more and more does so as the temperature rises.

All this is a truism in 1888, but it appears admirably new as well as true in 1811; and if De la Roche had not been removed by an early death, his would have not improbably been the greatest name of the century in the history of our subject; an honor, however, which was in fact reserved for another.

The idea of the identity of light and radiant heat had by this time made such progress that the attempt to polarize the latter was made in 1818 by Berard. We have just seen in Herschel's case how the most sound experiment may lead to a wrong conclusion, if it controvert the popular view. We now have the converse of this in the fact that the zeal of those who are really in the right way may lead to unsound and inconclusive experiment; for Berard experimentally established, as it was supposed, the fact that obscure radiant heat can be polarized. So it can, but not with such means as Berard possessed, and it was not till a dozen years more that Forbes actually proved it.

At this time, however fairly we seem embarked on the paths of study which are followed to-day, and while the movement of the main body of workers is in the right direction, it is yet instructive to observe how eminent men are still spending great and conscientious labor, their object in which is to advance the cause, while the effect of it is to undo the little which has been rightly done, and to mislead those who have begun to go right.

As an instance both of this and of the superiority of modern apparatus, we may remark,—after having noticed that the ability of obscure heat to pass through glass, if completely established, would

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be a strong argument in favor of its kinship to light, and that De la Roche and others had indicated that it would do so (in which we now know they were right),—that at this stage, or about 1816, Sir David Brewster, the eminent physicist, made a series of experiments which showed that it would not so pass. Ten years later, in view of the importance of the theoretical conclusion, Baden Powell repeated his observations with great care, and confirmed them, announcing that the earlier experimenters were wrong, and that Brewster was right; so that here all these years of conscientious work resulted in establishing, so far as it could be established, a wholly wrong conclusion in place of a right one already gained.

It may be added, that with our present apparatus, the passage of obscure radiant heat through glass could be made convincingly evident in an experiment which need not last a single second.

We are now arrived at a time when the modern era begins; and in looking back over one hundred and fifty years, from the point of view of the experimenter himself, with his own statement of the truth as he saw it, we find that the comparison of the progress of science to that of an army, which moves, perhaps with the loss of occasional men, but on the whole victoriously and in one direction, is singularly misleading; and I state this more confidently here, because there are many in this audience who did not get their knowledge of nature from books only, but who have searched for the truth themselves; and, speaking to them, may I not say that those who have so searched know that the most honest purpose and the most patient striving have not been guaranties against mistakes,—mistakes which were probably hailed at the time as successes? It was some one of the fraternity of seekers, I am sure, who said, "Show me the investigator who has never made a mistake, and I will show you one who has never made a discovery."

We have seen the whole scientific body, as regards this particular science of radiant energy, moving in a mass, in a wrong direction, for a century; we have seen that individuals in it go on their independent paths of error; and we can only wonder that an era should have come in which such a real advance is made as in ours.

That era has been brought in by the works of many, but more than by any other through the fact that, in the year 1801, there came into the world at Parma an infant who was born a physicist,

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as another is born a poet; nay, more; who was born, one might say, a devotee of one department of physics, that of radiant heat; being affected in his tenderest years with such a kind of precocious passion for the subject as the childish Mozart showed for music. He was ready to sacrifice everything for it; he struggled through untold difficulties, not for the sake of glory or worldly profit, but for radiant heat's sake; and when fame finally came to him, and he had the right to speak of himself, he wrote a preface to his collected researches, which is as remarkable as anything in his works. In this preface he has given us, not a summary of previous memoirs on the subject, not a table of useful factors and formulæ, not anything at all that an English or an American scientific treatise usually begins with, but the ingenuous story of his first love, of his boyish passion for this beloved mistress; and all this with a trust in us his readers which is beautiful in its childlike confidence in our sympathy.

I should need to abbreviate and injure in order to quote; but did ever a learned physical treatise and collection of useful tables begin like this before?

"I was born at Parma, and when I got a holiday used to go into the country the night before, and go to bed early, so as to get up before the dawn. Then I used to steal silently out of the house, and run, with bounding heart, till I got to the top of a little hill, where I used to set myself so as to look toward the East." There, he tells us, he used, in the stillness of nature, to wait the rising sun, and feel his attention rapt, less with the glorious spectacle of the morning light itself than with the sense of the mysterious heat which accompanied its beams, and brought something more necessary to our life and that of all nature than the light itself, so that the idea that not only mankind, but nature, would perish though the light continued, if this was divorced from heat, made a profound impression, he tells us, on his childish mind.

The statement that such an idea could enter with dominating force into the mind of a child will perhaps seem improbable to most. It will, however, be credible enough to some here, I have no doubt.

Is there some ornithologist present who remembers a quite infantile attraction which birds possessed for him above all the rest of the animated creation? some chemist whose earliest recollections are of the strange and quite abnormal interest he found as a child in making experimental mixtures of every kind of accessible house-

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hold fluid and solid? some astronomer who remembers that when a very little creature not only the sight of the stars, but of any work on astronomy, even if utterly beyond his childish comprehension, had an incomprehensible attraction for him? I will not add to the list. There are, at any rate, many here who will understand Melloni when he tells how this radiant heat, commonplace to others, was wonderful to his childish thought, and wrought a charm on it such that he could not see wood burn in a fireplace, or look at a hot stove, without its drawing his mind, not to the fire or iron itself, but to the mysterious effluence which it sent.

This was the youth of genius; but let not any fancy that genius in research is to be argued from such premonitions alone, unless it can add to them that other qualification of genius which has caused it to be named the faculty of taking infinite pains. Melloni's subsequent labors justified this last definition also; but I cannot speak of them here, further than to say, that, after going over a large part of his work myself, with modern methods and with better apparatus, he seems to me the man, of all great students of our subject, who, in reference to what he accomplished, made the fewest mistakes.

Melloni is very great as an experimenter, and owes much of his success to the use of the newly invented thermopile, which is partly his own. I can here, however, speak only of his results, and of but two of these,— one generally known; the other, and the more important, singularly little known, at least in connection with him.

The first is the full recognition of the fact, partly anticipated by De la Roche, that radiant heat is of different kinds, and that the invisible emanations differ among themselves just as those of light do. Melloni not only established the fact, but invented a felicitous term for it, which did a great deal to stamp it on recognition,— the term "thermochrose," or heat-color, which helps us to remember, that, as the visible and apparently simple emanation of light is found to have its colors, so radiant heat, the invisible but apparently simple emanation, has what would be colors to an eye that could see them. This result is well known in connection with Melloni.

The other and the greater, which is not generally known as Melloni's, is the generalization that heat and light are effects of one and the same thing, and merely different manifestations of it.

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I translate this important statement as closely as possible from his own words. They are that

"*Light is merely a series of calorific indications sensible to the organs of sight, or vice versa, the radiations of obscure heat are veritable* INVISIBLE RADIATIONS *of light.*"

The italics and the capitals are Melloni's own. He wishes to have no ambiguity about his announcement behind which he may take shelter; and he had so firm a grasp of the great principle, that, when his first attempts to observe the heat of the moon failed, he persevered, because this principle assured him that where there was light there must be heat. This statement was made in 1843, and ought, I think, to insure to Melloni the honor of being first to thus distinctly announce this great generalization.

The announcement passed apparently unnoticed, in spite of his acknowledged authority; and the general belief not merely in different entities in the spectrum, but in a material caloric, continued as strong as ever. If you want to see what a hold on life error has, and how hard it dies, turn to the article "heat," in the eighth edition of the "Encyclopædia Britannica," where you will find the old doctrine of caloric still in possession of the field in 1853; and still later, in the generally excellent "English Encyclopædia" (edition of 1867), the doctrine of caloric is, on the whole, preferred to the undulatory hypothesis. It is very probable that a searcher might find many traces of it yet lingering among us; so that Giant Caloric is not, perhaps, even yet quite dead, though certainly grown so crazy and stiff in the joints, that he can now harm pilgrims no more.

So far as I know, no physicist of eminence reässerted Melloni's principle with equal emphasis, till J. W. Draper, in 1872. Only sixteen years ago, or in 1872, it was almost universally believed that there were three different entities in the spectrum, represented by actinic, luminous and thermal rays. Draper remarks that a ray consists solely of ethereal vibrations whose lost *vis viva* may produce either heat or chemical change. He uses Descartes' analogy of the vibration of the air, and sound; but he makes no mention either of Descartes or of Melloni, and speaks of the principle as leading to a modification of views then "universally" held. Since that time the theory has made such rapid progress, that, though some of the older men in England and on the European continent

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have not welcomed it, its adoption among all physicists of note may be said to be now universal, and a new era in our history begins with it. I mean with the recognition that there is one radiant energy which appears to us as "actinic," or "luminous" or "thermal" radiation, according to the way we observe it. Heat and light, then, are not things in themselves, but whether different sensations in our own bodies, or different effects in other bodies, are merely effects of this mysterious thing we call radiant energy, without doing more in this than give a name to the ignorance which still hangs over the ultimate cause.

I am coming down dangerously near our own time, for one who would be impartial in dealing with names of those still living. In such a brief review of this century's study of radiant energy in other forms than light, it has been necessary to pass without mention the labors of such men as Pouillet and Becquerel in France, of Tyndall in England, and of Henry in America. It has been necessary to omit all mention of those who have advanced the knowledge of radiant energy as light, or I should have had to speak of labors so diverse as those of Fraunhofer, of Kirchoff, of Fresnel, of Stokes, of Lockyer, of Jannsen, and many more. I have made no mention, in the instructive history of error, of many celebrated experimental researches; in particular of such a problem as the measurement of solar heat, great in importance, but apparently most simple in solution, yet which has now been carried on from generation to generation, each experimenter materially altering the result of his predecessor, and where our successors will probably correct our own results in turn. I have not spoken of certain purely experimental investigations, like those of Dulong and Petit, which have involved immense and conscientious labor, and have apparently rightly earned the name of "classic" from one generation, only to be recognized by the next as leading to untrustworthy results, and leaving the work to be done again with new methods, guided by new principles.

In these instances, painstaking experiments have proved insufficient, less from want of skill in the investigator than from his ignorance of principles not established in time to enable him to interpret his experiments; but, if there were opportunity, it would be profitable to show how inexplicably sometimes error flourishes, grows, and maintains an apparently healthy appearance of truth,

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without having any root whatever. Perhaps I may cite one instance of this last from my own experience.

About ten years ago it was generally believed that the earth's atmosphere acted exactly the part of the glass in a hotbed, and that it kept the planet warm by exerting a specially powerful absorption on all infra-red rays. I had been trained in the orthodox scientific church, of which I am happy to be still a member; but I had acquired perhaps an almost undue respect, not only for her doctrines, but for her least sayings. Accordingly, when my own experiments did not agree with the received statement, I concluded that my experiments must be wrong, and made them all over again, till spring, summer, autumn and winter had passed, each season giving its own testimony; and this for successive years. The final conclusion was irresistible, that the universal statement of this alleged well-known fact, inexplicable as this might seem, in so simple a matter, was directly contradicted by experiment. I had some natural curiosity to find how every one knew this to be a fact; but search only showed the same statement (that the earth's atmosphere absorbed dark heat like glass) repeated everywhere, with absolutely nowhere any observation or evidence whatever to prove it, but each writer quoting from an earlier one, till I was almost ready to believe it a dogma superior to reason, and resting on the well-known "*Quod semper, quod ubique, quod ab omnibus, creditum est.*" Finally I appear to have found its source in the writings of Fourier, who, alluding to De Saussure's experiments (which showed that dark heat passed with comparative difficulty through glass), observes that if the earth's atmosphere were solid, it would act as the glass does. Fourier simply takes this (in which he is wrong) for granted; but, as he is an authority on the theory of heat, his words are repeated without criticism, first by Poisson, then by others, and then in the text-books; and, the statement gaining weight by age, it comes to be believed absolutely, on no evidence whatever, for the next sixty years, that our atmosphere is a powerful absorber of precisely those rays which it most freely transmits.

The question of fact here, though important, is, I think, quite secondary to the query it raises as to the possible unsuspected influence of mere tradition in science, when we do not recognize it as such. Now, members of any church are doubtless consistent in believing in traditions, if they believe that these are presented to

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them by an infallible guide; but are we, who have no infallible guide, quite safe in believing all we do, from our fond persuasion that in the scientific body mere tradition has no weight?

In even this brief sketch of the growth of the doctrine of radiant energy, we have perhaps seen that the history of the progress of this department of science is little else than a chapter in that larger history of human error which is still to be written, and which, it is safe to say, would include illustrations from other branches of science, as well as my own. But — and here I ask pardon if I speak of myself — I have been led to review the labors of other searchers from this standpoint, because I had first learned, out of personal experience, that the greatest care was no certain guaranty of final accuracy; that to labor in the search for a truth with such endless pains as a man might bestow if his own salvation were in question, did not necessarily bring the truth; and because, seeking to see whether this were the lot of other and greater men, I have found that it was, and that, though no one was altogether forsaken of the truth he sought, or on the whole review of his life as a seeker, but might believe he had advanced her cause, yet, when after long waiting, he saw once more what seemed her beautiful face, there was no absolute certainty that this might not be the mockery of error; and, doubtless, appeal might be made to the experience of many investigators here with the question, "Is it not so?"

What then? Shall we admit that truth is only to be surely found under the guidance of an infallible church? If there be such a church, yes! Let us, however, remember that the church of science is not such a one, and be ready to face all the consequences of the knowledge that her truths are put forward by her as provisional only, and that her most faithful children are welcome to disprove them.

What then, again? Shall we say that the knowledge of truth is not advancing? It is advancing, and never so fast as to-day; but the steps of its advance are set on past errors, and the new truths become such stepping-stones in turn.

To say that what are truths to one generation are errors to the next, or that truth and error are but different aspects of the same thing to our poor human nature, may be to utter truisms; but truisms which one has verified for one's self out of a personal experi-

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ence are apt to have a special value to the owner; and these lead, at any rate, to the natural question, "Where is, then, the evidence that *we* are advancing in reality, and not in our own imagination?"

There are many here who will no doubt heartily subscribe to the belief that there is no absolute criterion of truth for the individual, and admit that there is no positive guaranty that we, with this whole generation of scientific men, may not, like our predecessors, at times go the wrong way in a body, yet who believe as certainly that science as a whole, and this branch of it in particular, is actually advancing with hitherto unknown rapidity. In asking to be included in this number, let me add that to me the criterion of this advance is not in any ratiocination, not in any *a priori* truth, still less in the dictum of any authority, but in the undoubted observation that our doctrine of radiant energy is reaching out in every direction, and proving itself by the equally undoubted fact that through its aid nature obeys us more and more; proving itself by such material evidence as is found in the electric lights in our streets, and in a thousand such ways which I need not pause to enumerate.

And here I might end, hoping that there may be some lessons for us in the history of what has been said. I will venture to ask attention to but one. It is that in these days, when the advantage of organization is so fully recognized, when there is a well-founded hope that by coöperation among scientific men knowledge may be more rapidly increased, and when not only in the great scientific departments of government but everywhere, there is a tendency to the formation of the divisions of a sort of scientific army, not to say of a scientific church — that at such a time we should yet remember, that, however rapidly science changes, human nature remains much the same; and (while we are uttering truisms) let us venture to repeat that there is a very great deal of this "human nature" even in the scientific man, whose best type is one nearly as independent as nature itself, and one which will not always work best at the word of command. Let him then never forget that the history of science, scarcely less than of theology, warns him of the tendency of authority to exceed its proper sphere, and from without it, to define belief, and to impose obedience to doctrine.

Finally, if, turning to the future, I were asked what I thought were the next great steps to be taken in the study of radiant heat,

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I should feel unwilling to attempt to look more than a very little way in advance. Immediately before us, however, there is one great problem waiting solution. I mean the relation between temperature and radiation; for we know almost nothing of this, where knowledge would give new insight into almost every operation of nature (nearly every one of which is accompanied by the radiation or reception of heat), and would enable us to answer inquiries now put to physicists in vain by every department of science, from that of the naturalist as to the enigma of the brief radiation of the glow-worm, to that of the geologist who asks as to the number of million years required for the cooling of a world.

When, however, we begin to go beyond the points which seem, like this, to invite our very next steps in advance, we cannot venture to prophesy, and must content ourselves with the knowledge that through our study we are beginning to apprehend the full meaning of one of the early great ones of science, who described man as the meeting point of two infinities. That there is an infinity of space above him, man has long known, but that there is another absolute infinity, and the possibilities which lie in the infinitesimals of space, he is but beginning to realize. The secular movements, whose accomplishment demands more than a million years of time, he has already considered; but of the consequences which may result from a more careful study of actions occurring in the infinitesimals of time, and whose whole duration may be far less than the millionth of a second, he has hardly even yet begun to think; and these are but little portions of the ungarnered field of research, open to the student of that radiant energy which sustains, with our own being, that of all animated nature, of which humanity is but a part.

If there be any students of nature here, who, feeling drawn to labor in this great field of hers, still doubt whether there is yet room, surely it may be said to them, "Yes, just as much room as ever, as much room as the whole earth offered to the first man;" for everything that has been done in the past is, I believe, as nothing to what remains before us, and that field is simply unbounded. The days of hardest trial and incessant bewildering error in which your elders have wrought, seem over. You "in happier ages born," you of the younger and the coming race, who have a mind to enter in and possess it, may, as the last word here, be bidden to indulge in an equally unbounded hope.

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REPORTS OF COMMITTEES.

Report of the Committee on Indexing Chemical Literature.

The Committee on Indexing Chemical Literature respectfully presents to the Chemical Section its sixth annual report.

By the liberality of the Association the Committee secured 500 copies of the report for 1887, and these were distributed through the Secretaries of the American Chemical Society, the London Chemical Society, and the Washington Chemical Society, and directly by the Chairman of the Committee.

The Provisional List of Abbreviations of Titles of Chemical Journals, which formed Appendix B to the Report, was received by chemists with general approbation, and was reprinted in the Proceedings of the American Association for the Advancement of Science, Chemical News (London), American Chemical Journal (Baltimore), Journal of Analytical Chemistry (Easton), Journal of the American Chemical Society (New York), and was favorably noticed in the American Journal of Science (New Haven); this practically ensures its adoption.

During the year just closed, the Index to the Literature of the Spectroscope by Dr. Alfred Tuckerman has been printed by the Smithsonian Institution. This forms a work of about 400 pages, and contains 3,829 titles by 799 authors.

The Table of Specific Gravities for Solids and Liquids by Prof. F. W. Clarke is now in the compositor's hands and will soon be published by the Smithsonian Institution. This work is really a new and completely revised edition of Part I of the original "Constants of Nature."

An Index to the Literature of Columbium by Prof. Frank W. Traphagen has been completed and accepted by the Committee. Its publication has been undertaken by the Smithsonian Institution.

Dr. H. C. Bolton has compiled a Bibliography of Chemistry for 1887, the publication of which has been begun by the Smithsonian Institution.

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Several chemists project indexes and have made more or less progress on them. Mr. Arthur A. Noyes is engaged on an Index to the Literature of Ethylene; Prof. William P. Mason volunteers to index Methane; Mr. William Rupp undertakes to index Cæsium and Rubidium; Professor Traphagen plans to index Tantalum; Dr. H. C. Bolton has in preparation a Bibliography of the History of Chemistry including Biography and Bibliography; and Dr. Alfred Tuckerman is engaged in indexing the literature to Thermodynamics.

Several bibliographies merit brief mention; Dr. Jesse P. Battershall's Food Adulteration and its Detection (New York, 1887), contains an Appendix with the title:— "Bibliography including Periodicals, Reports and General Works chronologically arranged." This includes about 275 titles. The Second Annual Report of the N. Y. State Dairy Commissioner (1886) contains a Bibliography of Milk by Mr. Edward W. Martin (pp. 156–170), and a Bibliography of Butter, adulterations, testing, etc., by Prof. Elwyn Waller assisted by E. W. Martin and others (pp. 283–290).

Professor Wm. H. Seaman calls the attention of the Committee to several lists of United States Patents which relate more or less to applied chemistry. These lists on subjects indicated by their titles are found in the following works: Charles Thomas Davis, Manufacture of Leather; the same, Practical Treatise on the manufacture of Bricks, Tiles and Terra Cotta; the same, Treatise on Steam Boiler Incrustations; the same, Practical Treatise on the Manufacture of paper; Wm. T. Brannt, Treatise on Animal and Vegetable Fats and Oils. These are all published in Philadelphia, 1884–1887.

B. Tollens' Handbuch der Kohlenhydrate, Breslau, 1888, contains about 1500 references to the literature of carbohydrates.

Dr. Albert Brown Lyons publishes in the Pharmaceutical Era, under the title "Index Pharmaceuticus," a monthly list of books on pharmacy, chemistry and materia medica, as well as a list of original papers on these topics published in journals.

At the meeting of the British Association for the Advancement of Science held in 1886, a Committee was appointed for the purpose of reporting on the Bibliography of Solution. This Committee consists of Professors Tilden, McLeod, Pickering, Ramsay, Young, A. R. Leeds and Nicol (secretary), and presented its first report in 1887. This report sets forth the classification adopted,

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the list of journals (thirty-four in number) desirable to index, and a summary of work accomplished. From this summary it appears that 355 titles have been catalogued from 588 volumes of eleven different periodicals. The Committee of the B. A. recommends as members of the Committee other gentlemen who have access to the journals on the list and who would be willing to take an active share in the work.

The Committee of the American Association expresses its gratification that the work begun by them in 1882 is now being supplemented by chemists in Great Britain.

Persons desiring copies of reports, indexes and other information should address the chairman, care of the Smithsonian Institution, Washington.

H. CARRINGTON BOLTON, *Chairman*,
F. W. CLARKE,
ALBERT R. LEEDS,
ALEXIS A. JULIEN,
JOHN W. LANGLEY,
SAMUEL H. SCUDDER,
CHAS. K. WEAD,
Committee.

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Report of the Committee on Physics-teaching.

At the Philadelphia meeting of the Association in 1884, the undersigned were appointed a committee to consider and report upon the subject of Physics-teaching.

Brief reports of progress were made at the various meetings since that date, but it is only within the past year that the committee has been able to formulate and agree upon a final report which it now offers to the Association through the Council, at the same time respectfully requesting that it be discharged.

Before entering upon the consideration of the report, it seems proper to refer to some of the causes which have led to so long a delay in its preparation. Shortly after the appointment of your committee, consultation and correspondence with persons interested in the subject developed the great desirability of securing, if possible, the coöperation of the National Educational Association, many of the members of which were more deeply interested if possible, in certain phases of the subject to be considered, than the members of our own body. In accordance with this idea the council of that association, at its meeting in 1885, appointed a committee on Physics-teaching, consisting of Charles K. Wead, LeRoy C. Cooley, W. LeConte Stevens, W. F. Bradbury and James H. Baker.

This committee was not appointed for the specific purpose of coöperating with that of the A. A. A. S. in the preparation of a joint report, but an effort was made by the respective chairmen to secure a joint meeting of the two committees for this purpose.

This effort failed on account of the wide geographical distribution of the members. The committee of the National Educational Association prepared its report, however, and it was presented at the meeting of that body in 1887. It is probably well known to those who have especially interested themselves in this matter.

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An attempt was made to secure a meeting of your committee at Buffalo during the meeting of the Association in that city in 1886. A majority of the committee was present and an informal discussion of the subject was had, but it was thought best to defer any report until a full meeting could be held.

Accordingly a meeting was called at Washington, D. C., in December, 1887, and at this meeting, the first session of which was on December 24, all of the members of the committee were present except Professor Trowbridge, who found it impossible to attend.

At this meeting the subject was fully discussed and it was found that the members present were substantially in agreement as to the principal questions involved.

In presenting the conclusions reached it is not thought to be necessary or desirable to insist upon the importance of the study of physics or to offer arguments in favor of its introduction. This ground has been gone over so often and so thoroughly within the past decade that further discussion seems unnecessary.

As a matter of fact it may be said that nearly everything which can be justly claimed is now nearly everywhere admitted. Neither has it been thought necessary to go into detail as to methods of instruction.

The publication in the English language within a few years, of several excellent text-books of physics and a few laboratory guides of a high order of merit, together with a considerable advance in real scholarship among teachers, makes it possible to use the phrases "text-book work," "lecture work" and "laboratory practice" with a fair chance of being understood; yet it may be well to remark that where the latter is referred to, something very different from mere illustrative experimentation is meant, it being the opinion of the committee that the work in the laboratory should be quantitative rather than qualitative and always of as high a degree of precision as is possible with the appliances available.

In order to give definiteness to its conclusions the committee undertook to answer the following questions:—

1. In what grade of the public school should physics-teaching begin?

2. What should be the character of this first instruction? oral? by text-book? by laboratory methods? etc.

3. What should be the character of the physics-teaching in the

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high school? text-book? laboratory? text-book followed by laboratory? laboratory followed by text-book? or laboratory and text-book combined?

4. What knowledge of physics should be required for admission to college?

5. What should be the minimum course in physics for undergraduate students and what should be the nature of this course?

In answering these questions the needs of special students, or the requirements of scientific and technical schools and courses have not been considered. It may be fairly assumed that such students and courses and schools will take care of themselves.

The conclusions reached have reference only to the minimum training allowable in a course of study so adjusted as to give the student what we may continue to call, for want of a better name, "a liberal education."

1. In answer to the first question, it is the opinion of the committee that instruction in physics may begin, with profit, in what is generally known as the "grammar school." At the same time it is decidedly opposed to any general recommendation that it must begin there or in the primary school. Here, perhaps more than anywhere else, nearly everything depends on the teacher. One who has a strong liking for and a good knowledge of physics will be tolerably certain to succeed, while another not thus equipped for the work is equally certain to fail. Teachers belonging to the first class constitute an extremely small percentage of the grand total. In science-teaching in grades below the high school, much should be left to the individuality of the teacher. As a result of personal taste or previous training and study, one may give elementary instruction in botany, or in geology or in physiology so as to be a real inspiration to his class, while his instruction in physics might be so intolerably poor as to be unprofitable in the highest degree. The prevailing custom of many public schools which requires all teachers of a certain grade to teach physics is greatly to be regretted and every effort should be made to show school superintendents that it is a mistake which cannot be too quickly remedied.

The rapid advancement which is constantly being made in real scholarship among public school teachers will result in an increased and increasing number of those who are competent to teach physics; and while the committee is convinced that, as a means of real,

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honest, mental discipline, no branch of natural science is superior to physics, it would deprecate its forced introduction into the grammar school under circumstances likely to prove disastrous to the best interests of the science.

2. When taught in the grammar school, and by a competent teacher, it should be done mainly by and through illustrative experiments.

These may be of the simplest character, involving and exhibiting some of the fundamental principles of the science, and they should generally be made by the teacher, the pupil being encouraged to repeat, to vary and to extend. Habits of observation and of thought should be cultivated and such facts of the science as are based on or relate to the principles illustrated and developed should be presented. It is neither desirable nor necessary that any particular order should be followed in presenting the various divisions of the subject. The teacher should be guided by circumstances, such as the means at his disposal for experiment and illustration, and often by his own taste and predilection.

The ease with which apparatus for the illustration of the most important principles of physics can be improvised, even when the stock of materials at hand is very slender, puts the science in the front rank as to availability, and it is especially adapted to the requirements of certain schools both in town and country which, through their situation and surroundings, are restricted in their choice of a science subject. If to these facts we add another, which is universally admitted, that the physical properties of matter are the first to be recognized, the laws relating to which being, therefore, the first to arrest attention, it needs no argument to show that a competent instructor will find the study of physics one of the most important educational forces, even in the grammar school.

3. In any discussion of the character of instruction in physics in the high school, one fact of the utmost importance must not be lost sight of. It is that a large majority of the young people who are educated in the public schools receive their final scholastic training in the high school.

Its course of study must be in harmony with this fact, such provision as may be made for those who continue their studies in college or university, being merely incidental.

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The high school course in physics must include therefore a general treatment, which must of necessity be elementary in its character, of all the great divisions of the science.

It is likewise important that the student should be made acquainted, if only to a limited extent, with the methods of physical investigation and that he should be able himself to plan and carry out an attack upon some of the simpler problems of the science. The value of this work as an educational factor cannot be overestimated; it is the "walking alone" of intellectual infancy.

It is believed that these two very desirable ends can be reached without giving an undue share of the time and energy of the pupil to the subject. Assuming the high school course to consist of four years of three terms each, it is recommended that the study of physics should begin not earlier than with the third year; that it should continue through one year, three hours a week being devoted to it, not including the time necessary for the preparation of the lesson; and that during the first two terms the work should be text-book work, accompanied by illustrative experiments performed by the instructor and made as complete as his facilities will allow, while the last term should be devoted to simple laboratory exercises. It is hardly necessary to say that during the last term the three hours per week should be grouped into one exercise whenever possible.

Of the character of this laboratory practice it may be well to say that no attempt should be made to carry the pupil through a very great range of subjects. The end sought for can best be reached by a careful and more exhaustive study of a few problems which should be solved with the highest degree of accuracy attainable under the circumstances. As far as possible the pupil should be led to read and study books and papers bearing upon the particular subject which he has in hand. The time demanded by this plan, three hours per week for one school year, barely more than a hundred hours in all, is thought to be the least which is likely to produce results at all satisfactory, and it is urged that a vastly better arrangement is to allow the study of physics to run through two school years, giving it in time, the equivalent of five hours per week for one year.

It is well known that many teachers of physics, and many more who are not teachers of physics, insist on the introduction of lab-

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oratory practice from the beginning, some even going so far as to claim that the use of the text-book may be entirely dispensed with. Without desiring to enter into a discussion of this question, we wish to express, and with emphasis, our belief that laboratory practice is in general of little real use to the student unless he comes to it fairly well grounded in the fundamental principles of the science. The somewhat widespread opinion and practice, to the contrary, will be found, it is thought, to be one of those mistakes in which pedagogics seems to be caught on the rebound from other and generally more serious errors.

4. As to the requirements in physics for admission to college, it is sufficient to say that the course indicated above should be required for admission to any and all courses in the college.

5. In reference to the minimum course in physics for undergraduate students in the college, it seems important to avoid the mistake of asking too much.

In many institutions, and especially where the elective system largely prevails, it is possible at present for students to receive a degree and yet be almost absolutely ignorant of the principles of physics. It is the judgment of the Committee that a knowledge of this subject constitutes one of the necessary and essential elements of a liberal education, and a minimum course of three hours per week for one year is recommended. What is usually known as the junior year is most desirable for this work, as at that time the student is sufficiently mature and has acquired the necessary training in mathematics to enable him to make the best of what he does. It is recommended that this course consist entirely of text-book and recitation work, with lectures fully and completely illustrated on the professor's table.

It may possibly excite surprise that laboratory practice is omitted, but it will be remembered that this is a minimum course, in which it is not believed that the laboratory can be made to play a useful part. Whenever it is possible to increase the time devoted to the subject, this course may be and will be followed by a series of laboratory exercises. The nature of these must depend almost entirely on the skill and judgment of the professor in charge and on the facilities which he is able to command.

In any event it should be his aim to attend rather to quality than to quantity of work, and it should not be considered necessary for

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each student to work in or even to touch *all* of the great divisions of the subject.

In conclusion, your committee believes that whenever the Association speaks and in whatever it may say upon a subject so important as that under consideration, it should be governed by a wise conservatism, and that it should keep always in view the fact that when its suggestions and recommendations are in the real interests of the school and the college they are certain to be in the line of the advancement of science.

T. C. MENDENHALL, *Chairman*,
WM. A. ANTHONY,
H. S. CARHART,
F. H. SMITH,
Committee.

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Report of the Committee on the Preservation of Archæologic Remains on the Public Lands.

The Committee to memorialize Congress for the preservation of Archæologic remains upon the Public Domain has the honor to report as follows:—

After consultation it was agreed that it would be well if the following remains of early America could be preserved:—

Chaco Cañon, from the forks of Escavada cañon for a distance of eight miles up; also one mile back from the brink of the cañon walls on each side so as to include many interesting structures thereon.

Cañon DeChelly; Cañon Del Muerto; Walnut Cañon; The Ruin on Fossil Creek, an east branch of the Rio Verde, and about fifteen miles south of Camp Verde Military reservation; Ruins in Mancos Cañon; the Round Towers situated on the flat valleys of the lower Mancos.

The Cavate Lodges in the cinder cone, about eight miles east of Flagstaff, Arizona. Beside these groups of ruins, and dwellings, there are isolated remains in the territories of New Mexico, Arizona and Utah, numbering over forty, which demand preservation.

The Pueblos, which are not on treaty reservations, or grants; and the old Mandan and Arickaree village on the Fort Berthold Indian reservation, Dakota Territory, to be preserved, when they shall cease to be inhabited by the Indians. Also certain burial and village sites in Alaska.

Although every courtesy and assistance was rendered the Committee by the Geological Survey, it was found that field work would be required in every case but one, in order properly to designate the exact acreage needful to be set aside by Congress for the effectual protection of each ruin or group of ruins. This field work would require time, possibly two seasons, and involve expense.

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In order to meet this difficulty and to inaugurate the precedent of preserving archæologic remains upon the Public Domain, it was thought best to prepare a bill, which should reserve the one tract, the boundaries of which were already ascertained, and to direct a report upon other tracts needful for the preservation of archæologic remains to be made in the future to Congress by the Director of the Geological Survey. Heretofore there has been but one instance of legislation for the protection of the monuments of ancient America, that of the Legislature of Ohio, in reference to the Serpent Mound in that State. This relic including a tract of seventy acres has been bought and placed in the charge of the Trustees of the Peabody Museum of American Archæology and Ethnology of Harvard University, Mass.; and to Frederick W. Putnam, its curator, and Professor of American Archæology, is due the honor of making this first movement in behalf of American Archæologic culture.

The tract of land with ascertained boundaries, which Congress is asked to reserve, is situated on the Rio Grande, west of Sante Fé, New Mexico. It contains groups of cavate dwellings cut in the tufa, which show three distinct ages of occupancy: the two earlier ones dating back to an unknown period; the latest, it is thought, took place during the Spanish Wars of the sixteenth and seventeenth centuries. Upon the top of the walls of the cañons, stone pueblos were erected; these, however, have mostly fallen to ruins. The entire group is an interesting series of dwellings, both excavated and built, and is well worth preservation and study. Your committee have accordingly introduced the following bill into Congress with the promise of its speedy passage through both Houses:

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the tract of land in the Territory of New Mexico described as follows: beginning at the northwest corner of Cochiti Indian grant, and running north to the southeast corner of "Baca Location, No. 1;" thence east to the Ramon Vicil grant; thence southeasterly along such boundary to the eastern line of Bernallillo County; thence southward to a point directly east of the place of beginning; thence due west to place of beginning, is hereby reserved and withdrawn from settlement, occupancy, or sale under the laws of the United States; and all persons who shall locate or settle upon or occupy the same, or any part thereof, shall be considered trespassers and removed therefrom.

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SEC. 2. That said Reservation shall be under the exclusive control of the Secretary of the Interior, whose duty it shall be, as soon as practicable, to make and publish such rules and regulations as he may deem necessary or proper for the care and management of the same. Such regulations shall provide for the preservation from injury and spoliation all natural and archæological curiosities within said Reservation and their retention in their present condition.

SEC. 3. The Director of the Geological Survey is hereby directed to make a report to Congress specifying such other archæological remains existing upon the Public Domain, as should be preserved in the interests of science, together with a description of such tracts of land as it may be necessary to reserve in order to insure the protection of said archæologic remains from injury and spoliation.

Hoping that the efforts of the committee in behalf of Archæologic study may meet the approval of the Association,

Respectfully submitted,

ALICE C. FLETCHER,
T. E. STEVENSON,
Committee.

Washington, D. C., July 18, 1888.

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Report of the Committee to secure from Congress the Abolition of the Duties on Scientific Books and Apparatus imported into this country.

The committee makes the following report:

Shortly after its appointment Dr. J. S. Billings resigned, suggesting that a member from the West be selected to fill his place. Professor Langley, president of the Association, therefore appointed Prof. A. H. Worthen of Springfield, Ill., to the vacancy. Upon the death of Professor Worthen, which followed not long after, Prof. S. A. Forbes of Champaign, Ill., was selected by Professor Langley to fill his place.

The eastern members of the committee, Prof. J. R. Eastman and Prof. E. D. Cope, chairman, have held several meetings with the following results. The following resolution was adopted and signed by all the members:

Resolved: That there shall be admitted to this country, free of duty, all books in languages other than English; of books in the English language all single copies sent to periodicals issued not oftener than once a week; all books issued by governments and scientific societies and all other books not republished within a year after the first publication in an English-speaking country.

Also all apparatus, instruments and material to be used in scientific experiment or original research; decision as to the intention of the importer to rest with a committee of the U. S. National Academy of Sciences.

This resolution was placed in the hands of the Committee of Ways and Means of the House of Representatives of which the Hon. R. Q. Mills is chairman, through Hon. W. C. P. Breckinridge of Kentucky, one of its members. The resolutions were received with consideration and had the attention of the committee while engaged in framing what is known as the Mills Tariff Bill. The recommendations contained in the resolutions were partially incorporated into the bill in the following language (H. R. 9051, p. 1 and 7).

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, that on and after the first day

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of July, 1888, the following articles mentioned in this section, when imported, shall be exempt from duty: .

"Bibles, books and pamphlets printed in other languages than English, and books and pamphlets and all publications of Foreign Governments, and publications of Foreign Societies, historical or scientific, printed for gratuitous distribution."

This provision, although not covering the case of scientific publications produced in England, is a great advance over previous legislation on the subject.

As it is probable that the Mills bill in its present shape will not pass the Senate, and as the Senate is preparing a tariff bill as a substitute for it, the resolutions of your committee have been submitted to the committee of the Senate engaged in preparing this bill, of which Senator W. B. Allison is chairman. There is every reason to believe that the suggestions therein contained will receive the respectful consideration of that committee.

It has been hoped that some relief from the tax on knowledge at present imposed by the government of the United States might be largely relieved by the operation of the bill which has passed both houses of Congress, known as the Chace copyright bill. Such relief would really result, in the case of scientific books of which the sale should be sufficiently large to justify their republication in this country by foreign publishers, since they would then cease to be imported; but, unfortunately, the books most needed by students engaged in original research in this country are generally of a kind that are not republished, owing to the limited demand for them relatively to other classes of publications.

By resolution of the American Society of Naturalists, your committee has been made the recipient of the following preambles and resolutions and its request for the presentation of the same to Congress:

"Whereas, the cause of education in science is retarded by the restrictions placed by Congress on the importation of scientific books and apparatus: whereas we believe that advance in the arts and industries depends on the development of science and is impeded by the before-mentioned import duties, and that all restrictions on education and scientific research are unworthy of enlightened government: whereas the scientific books published abroad are absolutely essential to students and investigators, and are but rarely duplicated in this country: whereas the value of scientific apparatus is in nearly all cases dependent on the individuality of the maker: and whereas colleges and incorporated institutions are now permitted to import apparatus duty free, while private investigators, usually less able to afford expense, are obliged to pay duty, therefore

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Be it resolved, That ———— hereby requests the Representatives of the state of —— in the Congress of the United States to use all possible efforts to have placed on the free list, books pertaining to the physical, natural and medical sciences, and apparatus intended for purposes of scientific research or of education; and further be it

Resolved, That a copy of these preambles and resolutions be forwarded to each member of Congress."

These resolutions were sent, by resolution of the same society, to the faculties of the universities and colleges throughout the United States for their approval and signature. Replies expressing this approval and signed by the faculties, or their accredited officers, were received from the following institutions:

The American Philosophical Society, Philadelphia.
The Franklin Institute, Philadelphia.
The Academy of Natural Sciences, Philadelphia.
The County Medical Society, Philadelphia.
The Society of Arts, Boston.
Brown University, Providence, R. I.
Bryn Mawr College, Pa.
Wellesley College, Mass.
Iowa College, Iowa.
Michigan University, Ann Arbor, Mich.
Wesleyan University, Middletown, Conn.
Naval Academy, Annapolis, Md.
Middlebury College, Vt.
Hamilton College, Clinton, N. Y.
Swarthmore College, Pa.
Adelbert College, Ohio.
Williams College, Williamstown, Mass.
College of the City of New York.
University of Alabama, Tuscaloosa, Ala.
Lafayette College, Easton, Pa.
Amherst Agricultural College, Amherst, Mass.
Haverford College, Pa.
Smith College, Mass.
Columbian University, Washington, D. C.
Stevens Institute of Technology, Hoboken, N. J.
University of Indiana, Indiana.
Lehigh University, Bethlehem, Pa.
University of California, Berkeley, Cal.
Hobart College, New York.
College of Physicians and Surgeons, New York City.
University of North Carolina, N. C.
Columbia College School of Mines, New York City.
Union College, New York.
Kenyon College, Ohio.

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Northwestern University, Evanston, Ill.
Marietta College, Ohio.
University of Virginia, Charlottesville, Va.
Cornell University, Ithaca, N. Y.
Hampden Sidney College, Va.

As regards the removal of duty from imported philosophical and scientific apparatus, your committee cannot report much progress. Our efforts have been mainly directed to the removal of the duty on books, under the belief that success in this direction will prepare the way for further progress. We have not, however, neglected this important subject. The Mills tariff bill thus refers to it (pp. 27 and 32):

(p. 32.) "And on and after October first, 1888, in lieu of the duties heretofore imposed on the articles hereinafter mentioned in this section, there shall be levied, collected and paid the following rates of duty on said articles severally:"

"Philosophical apparatus and instruments, twenty-five per centum ad valorem."

Your committee hope to be able to secure the total abolition of the duties on foreign books of science, and the great reduction, if not abolition, of those on apparatus. We base this hope on the activity in the direction of change in the existing laws on this subject, at present existing in Congress, and the evident desire of the representatives of both the great political parties of the country to legislate for the best interests of their constituents, as they understand them. At the moment of preparing this report it is not possible to announce any final result of the action of your committee, but it is quite possible that improved legislation may be attained by the time of the meeting of the Association to which this report is made.

In conclusion we feel that what is needed to effect the result desired, is a continuation of the effort, already commenced, of vigorous protest against the laws on the subject as at present existing; laws which obstruct knowledge at its fountain-head; which impose onerous burdens on a class which works gratuitously for the public good, and which place our country in a false position among the enlightened nations of the earth.

EDW. D. COPE, Philadelphia, *Chairman*,
J. R. EASTMAN, U. S. Naval Observatory, Washington,
S. A. FORBES, Champaign, Ill.,
Committee.

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Report of the Committee on Anatomical Nomenclature with special reference to the Brain.

With regard to encephalic nomenclature, the committee understand that three distinct tasks are to be performed:

A. The preparation of a list of those names which they regard as worthy of adoption; the terms to be in Latin, with appropriate equivalents (etymologically similar so far as possible), in English, French, German and Italian.

B. The formulation of comprehensive principles of anatomical nomenclature, and of rules that should govern the selection of existing terms and the formation of new ones.

C. The recommendation of descriptive terms to be used in indicating the position and direction of encephalic parts with respect to one another and the longitudinal axis.

These tasks are both extensive and difficult, and other and imperative duties have prevented the committee from devoting to them as much time as they had hoped; moreover, their attention has been called quite recently to certain publications in which the principles of anatomical nomenclature are somewhat fully discussed but which it has not been possible to examine as yet with the care which they deserve.

The committee therefore ask to be continued, and hope to have made visible progress by the time of the next meeting of the Association.

Burt G. Wilder, *Chairman*,
Harrison Allen,
Frank Baker,
T. B. Stowell,
Committee.

Note.—The undersigned was out of the country at the time the above report was prepared and submitted, but now expresses his concurrence therein.

Henry Fairfield Osborn.

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Report of Committee on International Congress of Geologists.

The committee on the International Geological Congress report that the papers prepared and brought to the Association at its meeting last year have been transmitted to the Congress, which is about to assemble in London. Their duties in this respect are done. The treasurer, Prof. H. S. Williams, reports that all the expenses incurred by the committee are paid and the accounts closed.

The secretary, Dr. Persifor Frazer, has in hand a subscription list for copies of the geological map of Europe, prepared by the International Geological Congress. One hundred copies are proposed to be subscribed for here and it is reported that ninety-four subscribers are secured.

The invitation for the Congress to hold its next session, that of 1891, in this country will be presented at the coming session of that Congress. With these duties performed the functions of the committee will end, and future business of the International Congress devolves upon the A. A. A. S. and the American Geological Society, which it is expected will act with Section E of this Association.

Report presented by

George H. Cook.

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Report of Special Agent of Transportation for the Association to act with the Local Committees.

In regard to the efforts to secure reduced fares for members attending the meeting: — The membership of the A. A. A. S. being distributed over so large an extent of country several distinct Passenger Agents' Associations are included therein, each of which require separate negotiations in obtaining concessions. The rules and regulations of the associations are unlike, therefore unity and uniformity of action cannot be obtained of all, especially from those most distant from the place of meeting.

The rules of the principal associations are now such that the chairman of the association can, under definite limitations, grant concessions for fares without submitting the question to a vote of the passenger agents of the association.

The A. A. A. S. can feel reasonably certain of obtaining a concession in the Passenger Association where the meeting is held, also in the adjacent associations, of a fare and one-third for the round trip, on the certificate plan and three days' limit.

The requirements of such a concession are that one hundred members attend the meeting from two of the associations. This does not meet all cases, but is the best which can be obtained without a special vote by the different Passenger Agents' Associations, which is no easy matter to obtain.

For the Cleveland meeting I applied to the principal associations for a concession of our fare for the round trip and an extension of the three days' limit. Neither was granted.

Before the associations will take any official action for a reduction of rates, an application must be filed stating the name of the organization, place of meeting, date of meeting, the probable number in attendance and the name of the secretary who will sign the certificates.

All of this information can be furnished by the agent except the name of the secretary who is to sign the certificates.

The name of the latter should be designated by the Local Committee for the next meeting by the first of January, 1889.

The date of the meeting should be counted from the time the council meets and adjourns.

P. H. Dudley, *Honorary Agent.*

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SECTION A.

MATHEMATICS AND ASTRONOMY.

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ADDRESS

BY

PROFESSOR ORMOND STONE,

VICE PRESIDENT, SECTION A.

MOTIONS OF THE SOLAR SYSTEM.

As in the moral world unselfishness stands high above all other virtues, so in science the interest in any subject depends principally upon its relation to other subjects. Thus pure mathematics derives its chief value from its applications or from the possibility of application. Astronomy affords the highest opportunities for the exercise of genius in the development of geometrical analysis. But its real interest does not centre in the analysis itself, but in its application to the study of the motions of the physical universe; nor is it the motions themselves which excite our chief interest, but rather those philosophical questions which relate to the origin, structure and unity of the universe.

No other hypothesis has been suggested which offers such direct and complete answers to most of these questions as Newton's law of gravity. It is but natural, therefore, that the majority of the problems which arise in regard to the motions of the solar system should have their origin in an effort to confirm this law, so remarkable for its wonderful simplicity, yet so complicated in its consequences, that many of the most important problems arising therefrom remain still unsolved.

The first attempt to apply Newton's law to all the motions of the solar system was made by Laplace, and to-day there exists no work in science which for boldness of design, grandeur of outline,

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and success of accomplishment, surpasses the *Mécanique Céleste.* Nevertheless, when Lindenau and Bouvard undertook to compute their tables of the motions of the planets, a complete revision of Laplace's theory was found necessary. This was due to the fact that Lindenau and Bouvard had more numerous and more accurate observations with which to compare Laplace's theory than the latter had employed in its formation. Every advance in accuracy of observation demands a corresponding advance in theory.

As no general solution of the problem of more than two bodies has thus far been obtained in finite terms, in any analytical discussion of the motions of any dynamic system, it is necessary to resort to the use of infinite converging series. Now, it is a peculiarity of such series, that the expressions involving small quantities of any given order of magnitude are generally more complicated than those of a lower order, although in general the former are much smaller than the latter. Mr. Hill, in speaking of his computation of the inequalities of Jupiter and Saturn, especially mentions that more time was consumed in computing terms of three dimensions than in computing those of two. On the other hand, every additional observation adds to the work of the computer. Such are some of the difficulties which beset the computer in his efforts to obtain numerical solutions of problems in celestial mechanics.

So enormous, indeed, is the labor involved, that there exists besides those mentioned only one other complete set of theories and tables of the motions of the principal planets, that of Leverrier. Leverrier's tables of the inner planets are now nearly thirty years old, and those in use to-day, if we except Hill's tables of Venus, which were published in 1872, in which Leverrier's theory was employed, but corrected by comparison with observations. Leverrier's tables of the outer planets are much later, having engaged his attention almost to the day of his death. His tables of Jupiter and Saturn were published in 1876 and those of Uranus and Neptune during the following year. Bouvard's tables of Jupiter and Saturn preceded those of Leverrier no less than fifty-five years.

Newcomb's tables of Neptune were published in 1865, those of Uranus in 1874. Hill's Theory of Jupiter and Saturn which has for years occupied his attention has at last been completed, and he is now engaged in preparing tables therefrom. These are intended to form a part of a complete series of tables of the principal planets now being prepared under the direction of Professor New-

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comb, at Washington. Another such series is also being prepared by Professor Gyldén, at Stockholm.

The values of the coëfficients of the terms of short period in the motions of the principal planets are now pretty well known; and the same might be said of the secular variations, were it not for the difference between theory and observation which exists in regard to the motion of the perihelion of Mercury which was discovered by Leverrier, and has been confirmed by Newcomb in a discussion of the observations of the transits of Mercury extending over a period of more than two centuries. The cause of this difference still remains unknown. Whether the law of gravity requires modification, or the difference is produced by the attraction of unknown matter in the neighborhood of the sun or Mercury, or whether some force other than gravity effects the motion of Mercury without being appreciable in the case of the planets more remote from the sun, we cannot tell. There is evidently no planet or group of planets as Leverrier supposed between Mercury and the sun; for, although careful search has been made during recent eclipses in the hope of discovering one or more such bodies, it has always been in vain. The objects seen by Watson and Swift during the eclipse of 1878 were undoubtedly fixed stars. The claim has, indeed, been made that such bodies had been observed crossing the sun's disc, but no such phenomenon has been seen by any skilled observer. Professor Newcomb thinks that even disintegrated matter in sufficient quantity to produce the effect under consideration would shine more brightly than the zodiacal light, and, unless situated near the plane of Mercury's orbit, would produce a secular variation of the node which does not exist. Tisserand has computed the secular variation of the planets employing Weber's Electrodynamic law of gravity, but the difference of the value of the motion of the perihelion of Mercury thus obtained from that given by Newton's law is much smaller than the discordance derived from observation. The completion and comparison with observations of the new theory of the four inner planets now being prepared under the direction of Professor Newcomb will be awaited with interest with the hope that it may throw new light upon this interesting subject.

Of the satellites of the solar system our moon has naturally attracted more attention than all the others combined. The only recent original tables of the moon's motions are those of Hansen.

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These, like Leverrier's tables of the inner planets, are now more than thirty years old. These tables have been compared with observations, and agree fairly well with those made during the century preceding their publication, but not with those made before or since that time.

Halley was the first to call attention to the existence of a secular acceleration of the moon's longitude. Laplace made a numerical application of Lagrange's theory of secular variation, and thus explained the lunar acceleration on theoretical grounds. Adams, however, was the first to obtain a practically correct theoretical value of this acceleration (6″), which has since been confirmed by Delaunay and others. Hansen, on the other hand, by a comparison of his Lunar Theory with historical statements which he assumed to refer to certain ancient total eclipses of the sun, concludes that the acceleration is 12″, or twice that found by Adams. Professor Newcomb, on the other hand, considers the employment of these eclipses for the determination of the secular variation as entirely unwarranted. If historical statements of the ordinary events of those times are unreliable, especially so must be statements in regard to scientific phenomena made by unscientific men, and often given at second-hand. Even if we assume in any given case that the statement refers to a total eclipse of the sun, the locality where the eclipse was total is nearly always extremely uncertain. Accordingly, Professor Newcomb, in determining the value of the acceleration, limits himself to two sources of evidence, the Ptolemaic eclipses of the *Almagest*, and the Arabian eclipses contained in *Le Livre de la Grande Table Hakémite*. From these he concludes that we cannot suppose the acceleration much greater than 8″.3 without supposing systematic errors which seem quite improbable. In fact, if the Arabian observations, which are more accurate than those of Ptolemy, be alone combined with modern observations, the result is only 7″, a value but little greater than the theoretical value.

Dr. Ginzel has made an extensive comparison of Hansen's theory with accounts of total eclipses of the sun of the middle ages which have been found in the many cloisters scattered over the continent of Europe. From these accounts he has estimated the differences between the distances north or south, in degrees of latitude, of the average places of observation from the lines of central totality as obtained from Oppolzer's eclipse tables, which are based

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upon Hansen's theory. From these differences of latitude he has formed equations of condition from which to obtain corrections to the coëfficient of acceleration and the mean motions in longitude, argument of latitude, and mean anomaly. Having solved his equations of condition, he finds that certain ancient eclipses are also fairly well represented by the corrections obtained. He, accordingly, includes these in a new set of equations, rejecting, however, two of the later eclipses which in the first solution had given the largest residuals. The solution of this second set of equations gave him a second set of corrections much smaller than those first obtained and representing the old eclipses much better, and finally concludes that Hansen's value of the acceleration requires a change of only a little more than 1″. A careful inspection, however, of his residuals shows that these are almost exactly identical in both solutions for those eclipses which are common to both; whence, it may be concluded that his solution depends in reality upon the ancient eclipses alone, which in turn should be accepted with caution, or perhaps rejected entirely on the grounds so ably discussed by Professor Newcomb. From the evidence we have, it seems probable, though not positive, that a small secular residual still remains unexplained.

Several hypotheses have been suggested in explanation of the supposed discordance between the observed and theoretical values of the acceleration. In a complete theory of the moon, there should exist no terms which increase with the time, but in place of the so-called secular terms, there should be terms of very long period; but the determination of these terms of very long period is a problem as yet unsolved. Still, it would hardly seem probable that there exists any term of this character not taken account of during the few centuries over which observations have extended, of sufficient size to account for the large difference assumed by Hansen. Another hypothesis is the assumption that the earth is changing the velocity of its rotation on its axis either by reason of the friction produced by the tides of the ocean, as originally suggested by Kant and afterwards revived by Mayer, Ferrel, and Delaunay, or by reason of friction produced by bodily tides on the assumption that the earth is partially viscous as assumed by Darwin. The acceleration might also be accounted for by assuming that the law of gravity, as given by Newton, is only a very close approximation to the true law of nature, or by assuming that the motion of the moon is affected by the action of other forces acting independently of grav-

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ity. The supposition suggested by Oppolzer that the moon is retarded by the impact of meteors is entirely inadequate, nor is it reasonable to suppose that there exists a resisting medium of sufficient density to produce an appreciable effect on the moon's motion.

An examination of the residuals found by Professor Newcomb in his researches on the motions of the moon would seem to indicate that, aside from the acceleration, there exist appreciable unexplained inequalities of somewhat long period. It hardly seems possible that the rotation of the earth on its axis could be so irregular as to be the cause of these inequalities. We should rather, it seems to me, look for an explanation to a more accurate knowledge of the theory of the moon's motion based upon the law of gravity, or to the existence of other unknown forces.

The only other theory of the moon comparable with Hansen's is that of Delaunay, which forms Vols. XXVIII and XXIX of the Memoirs of the French Academy. The method there adopted is so elegant that in Mr. Hill's opinion it cannot fail to become in the future the classic method of treating all problems of celestial mechanics. This theory, however, is limited to a determination of the inequalities in the motion of the moon due to the action of the sun on the hypothesis that the orbit of the earth is a pure ellipse. Mr. Hill has since determined the inequalities due to the ellipticity of the earth's figure and a portion of the disturbance produced by Jupiter. The subsidiary inequalities, however, due to the inequalities in the earth's motion and to the disturbance of the other planets remain still to be determined.

Delaunay's method differs from that of Hansen in that the inequalities determined are not expressed numerically but only symbolically in terms of arbitrary constants.

The longitude and latitude can be more accurately confirmed by observation than the radius vector, which is not observed directly. Delaunay determined the inequalities of the longitude and latitude to terms of the seventh order, or, when the convergence of the series was found too slow, to terms of the eighth and ninth order. The radius vector, however, he carried only to terms of the fifth order, which is not even sufficient for a determination of the moon's parallax. Professor Adams has, however, since calculated the inequalities of the radius vector of the moon to the same degree of accuracy Delaunay obtained for the latitude and longitude.

A numerical comparison made by Professor Newcomb between

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Hansen's and Delaunay's theories shows that the solar terms of short period are now fairly well known. In view of the magnitude of the work involved in a determination of the motion of the moon, it is remarkable how few errors have been detected in the work of these masters of celestial mechanics. So far as he has gone, Delaunay's theory is, so far as I am aware, absolutely perfect. This cannot of course be said in regard to Hansen's, since his operations are all numerical, and therefore subject to inaccuracies arising from an imperfect knowledge of the values of the constants employed. A few additional errors have also been detected. Hansen assumed that the centre of gravity of the moon does not agree with the centre of the figure, an apparently unwarranted hypothesis. The coefficient of the largest inequality thus introduced is, however, only one-third of a second. A small inequality was accidentally introduced into the tables with the wrong sign, and one other more important term has been found to have no theoretical existence. While the coëfficients of the inequalities upon which Hansen's tables are based seem to be pretty well known, I am not aware that the tables themselves have been sufficiently checked except by comparison with observations. Apparently, the great desideratum now is a set of tables computed from Delaunay's theory in a completed form, or computed in some other way absolutely independently of Hansen's. Until Hansen's tables are thus checked, it is questionable whether it can be safely said that the motion of the moon cannot be completely accounted for by the law of gravity.

Among the many important investigations in regard to the moon's motion, not already referred to, may be mentioned Dr. Hill's remarkable researches, especially his memoir on the motion of the lunar perigee, and Professor Adams's paper on the motion of the moon's node. In these, instead of first determining inequalities of the first order in regard to the mass of the disturbing body, the terms which are independent of the eccentricities and inclination are first obtained; and afterwards those which involve the first powers of the eccentricities and the sine of the inclination; and so on.

Probably the greatest very recent loss to astronomy was sustained in the death of Oppolzer. The remarkable career of this distinguished astronomer during the past quarter of a century inspired the hope that the researches in the lunar theory which he had only just entered upon at the time of his death would result in a veritable addition to our knowledge of this subject.

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The detection of the two satellites of Mars by Professor Hall with the great equatorial at Washington may be considered the most interesting recent achievement in pure discovery. Phobos, the inner of these, is the only satellite in the solar system which revolves about its primary in less time than it takes the primary to rotate on its axis, and hence the only satellite which rises in the west and sets in the east.

The accuracy of the values of the masses of the planets obtained from discussions of orbits of comets and asteroids varies greatly according to the size of the inequalities produced. If the principal inequality is large and the body has been carefully observed through a long period by a large number of observers, the result ought to be accurate and practically free from personal error. But the most favorable circumstances seldom occur, and it was not till the discovery of the satellites of Mars that a means was offered for the accurate determination of the mass of this planet. No satellites of Venus and Mercury have as yet been discovered, and the values at present assumed for the masses of those planets are very uncertain.

In 1788, just one hundred years ago, Laplace published a complete theory of Jupiter's satellites. This theory is still the basis of the tables now in use. Souillart's analytical theory of these satellites appeared in 1881. His numerical theory was completed only within the last year, and tables therefrom still remain to be formed.

Titan, the largest satellite of Saturn, was discovered by Huygens in 1655; soon afterwards Cassini added four to the number; a century later two more were added by Herschel; and, finally, Hyperion was discovered by Bond in 1848. Bessel made a careful investigation of the orbit of Titan and therefrom obtained a value for the mass of Saturn which since that time has been generally employed in the determination of the perturbations produced by that planet. The general theory of the Saturnian system which he commenced, he did not live to finish. It may be found in its incomplete condition in the *Nachrichten*. "This memoir," as Professor Hall remarks, "is still the most comprehensive investigation we have of the differential equations of this system and of the various forms of the perturbative function arising from the figure of the planet, the ring, the action of the satellites on each other, and the sun."

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Our knowledge of the motions of the satellites of Saturn, with the exception of Titan, was very meagre until quite recently. This system of satellites is, in many respects, the most interesting in the solar system, and its form is quite analogous to that of the primary system. The number of members is the same, and Titan plays very much the same role in the one system that Jupiter does in the other. Since its erection, the great equatorial of the Washington Observatory has been chiefly devoted to observations of the numerous satellites of the outer planets. Professor Hall has published a discussion of his observations of all the satellites of Saturn except Hyperion, but omitting a discussion of the motion of the node of Iapetus. The mass of Saturn obtained by Professor Hall from micrometric measures of position angles and distances is smaller than that obtained by Bessel. The difference is perhaps due to the difference in personal errors in the measurements of the satellites when in different positions with regard to the primary. This error is increased by the fact that when the position of the satellite is compared directly with the primary, one of the micrometer wires must bisect the disc or we must measure from one of the edges of the planet. In the case of Saturn, the difficulty is further increased by the presence of the rings. To avoid these difficulties, Otto Struve has suggested the comparison of the positions of the satellites with one another instead of with the planet. Within the last two or three years Hermann Struve has made such a series of observations, with the great refractor of the Pulkowa Observatory, resulting in a mass of Saturn practically the same as that of Bessel.

A difficulty in the determination of a correct theory of the motions of Saturn's satellites is the fact that there are a number of cases of approximate commensurabilities in the ratios between their so-called mean motions. For example, the mean motion of Iapetus is almost exactly one-fifth that of Titan, Dione one-half that of Enceladus, and Thetus one-half that of Mimas. But the most interesting case is that of Hyperion, whose mean motion is very nearly three-fourths that of Titan. In this case, there is the additional difficulty that their distance from one another is only about one-seventh as great at conjunction as at opposition. The apparent eccentricity of Hyperion's orbit is principally due to the perturbations produced by Titan. As a consequence, Hyperion is always at apo-saturnium when in conjunction with Titan. The values for the mass of Titan obtained from discussions of the motion of Hyperion by Mr. Hill and myself agree closely with one

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another, and with that obtained by Hermann Struve from the motion of the node of Iapetus. The values previously obtained by Newcomb and Tisserand are evidently too small.

Our knowledge of the motions of the satellites of Uranus and Neptune depends almost entirely on the observations made at Washington. Quite accurate determinations of the masses of these two planets have been obtained from them. The theory of their satellites offers no other points of special interest. The large secular motion of the plane of Neptune's satellite to which Marth has called attention needs confirmation; so that we may say that with the exception of the lunar acceleration there is little evidence that any of the satellites of the solar system move otherwise than in exact accordance with Newton's law of gravity.

The discovery of the asteroids began with the century. Only four were detected by the end of 1807, and it took forty years to double this number. Since that time, however, their discovery has progressed with ever increasing activity, until the number of these diminutive bodies has reached two hundred and seventy-eight, and is now increasing at the rate of nearly one hundred to every decade. The asteroids individually possess little interest of their own; but, on account of their motions, and on account of the assistance which their observation offers in the solution of other problems, they have already played an important part in the history of astronomy. The discovery of Ceres led to the composition of the *Theoria Motus*, and a demand for a more accurate knowledge of their motions was the origin of Hansen's *Auseinandersetzung*. Several of the asteroids approach Jupiter sufficiently close to offer a valuable means for the determination of the mass of that planet. On the other hand, another of the asteroids is at times actually nearer to the sun than Mars, but unfortunately the inclination of its orbit is very great.

The discovery of new asteroids should be encouraged in the hope that one or more may be found having inequalities in their motions produced by Mars and the earth of sufficient amount to render observations of them valuable for the determination of the mass of Mars and of the earth, the mass of which is, strange to say, not nearly so well known as those of Jupiter and Saturn. The masses of the latter are obtained from the observed distances of their satellites, while in the case of our own satellite the distance is the one quantity which it is impossible to observe.

The number of asteroids is so great that they have been the fre-

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quent subject of statistical investigation. Perhaps the most important earlier investigations of this sort were those of d'Arrest and Newcomb, which threw doubt upon the hypothesis of Olbers, that the asteroids were the fragments of an explosion of a larger planet. The systematic grouping of their nodes and perihelia which exists, was shown by Newcomb to be the effect of perturbation. A clearer light has been thrown upon this subject, more recently, by Glauser and Newton. As a result of the action of Jupiter, the orbit of each asteroid has a motion about the orbit of that planet. These motions being unequal, there is a tendency toward a uniform distribution of the nodes on the orbit of Jupiter. Glauser shows that the observed grouping of the nodes on the ecliptic is a subsidiary result of such a uniform distribution, which, however, is slightly disturbed by the action of Saturn. Newton had previously found that the centre of gravity of the poles of two hundred and fifty-one asteroid orbits, considered as points of equal weight, lies within half a degree of the pole of Jupiter's orbit, and in fact regarding this centre of gravity as the pole of the mean plane of the asteroid orbits, that this mean plane lies nearer to the plane of Jupiter's orbit than to the orbit plane of any individual asteroid. On the other hand, if weights be given derived from the observed magnitudes of the asteroids, the position of their mean plane as found by Svedstrup differs greatly from that of Jupiter.

Kirkwood concludes, from an inspection of a table of the mean distances of the asteroids, that those parts of the asteroid zone in which a simple relation of commensurability would obtain between the period of a minor planet and that of Jupiter, are distinguished as gaps or chasms similar to the intervals in Saturn's ring. This much can, at least, be said that eighty-five per cent of the asteroids have mean motions greater than twice and less than three times that of Jupiter, and the mean motions of none approximate closely either of these, the two simplest ratios possible. The next simplest ratios lie beyond the limits of the zone; that is, there are no asteroids having mean motions nearly equal to or less than three halves that of Jupiter, and none nearly equal to or greater than four times that of Jupiter. There are other cases, however, in which the mean motions approximate very closely to commensurabilities which, although more complicated than those just mentioned, are still comparatively simple.

The labor of determining the general perturbations and computing tables of an asteroid is as great as in the case of a major

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planet. It is no wonder, therefore, that tables have been prepared for scarce a dozen of these small bodies, and that these are already out of date. An examination of the Berlin *Jahrbuch* will show how much labor is required to determine their motions with sufficient accuracy to identify them, to prevent them from being lost, and to distinguish them from any new ones which may be detected. So far as we are yet aware, their motions are in exact accordance with Newton's law of gravity. Any divergence from that law, if any exist, will require many years, perhaps centuries, of careful and patient investigation to determine.

Many comets being visible to the naked eye, records of them extend back to very early times. As the number of persons interested in astronomy has increased, and especially since the discovery of the telescope, the number of these records has continually enlarged. As, however, the ease with which comets are detected does not, beyond a certain limit, increase with the aperture of the telescope employed, as in the case of asteroids, the rate of their discovery has not increased as rapidly as that of the minor planets. Before 1867 there were only eight periodic comets which had each been observed at at least two appearances. Since that time three comets of short period have been discovered, all by Tempel, which have been observed at at least two appearances. More recently, five comets of short period have been discovered by others, which, with perhaps one exception, had not apparently been observed before, and the time for whose next appearance has not yet arrived. The exception is Findlay's 1886 VII which may be the same as de Vico 1844 I. Quite recently returns have also been observed of two comets of long period, those of Olbers and of Pons.

Of well-known comets of short period Encke's, which has the shortest period of any, possesses the greatest interest to the student of celestial motions, since it was from a discussion of the orbit of this comet that Encke detected evidence of the existence of a resisting medium which produces an acceleration in the comet's mean motion. A more recent investigation by von Asten confirmed Encke's hypothesis so far as the observations from 1819 to 1868 were concerned, but showed that this acceleration did not exist after 1865. Backlund, who took up the problem after the death of von Asten, finds that while the latter result was due to the use of erroneous formulæ in the computation of the terms of the second order for the period 1865 to 1868, the acceleration of the mean motion is nevertheless diminishing. Backlund ends his

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memoir by a theoretical consideration of the action of a resisting medium, and concludes that facts agree better on the assumption that the medium acts directly as the velocity, and inversely as the square of the radius vector. The investigations of Oppolzer and Haerdtl indicate that there is an acceleration also in the mean motion of Winnecke's comet. These two are the only comets whose motions so far as they are known cannot be fully satisfied by Newton's law. The large eccentricities of the orbits of periodic comets have thus far rendered it impracticable to compute tables of their motions as has been done in the case of planets and their satellites. The general perturbations of Encke's comet have indeed been partially determined, but the results reached, though interesting and valuable, can by no means be considered satisfactory.

We have thus glanced briefly at the present condition of our knowledge of the motions of the principal bodies of the solar system. Only four cases have been found in which we cannot fully explain these motions so far as known, by Newton's law of gravity. The unexplained discordances are the motion of the perihelion of Mercury, and the accelerations of the mean motions of the moon and the two periodic comets just named. But in each case, except perhaps the first, there exists a plausible explanation other than a modification of Newton's law.

If we go beyond the solar system, we cannot tell whether Newton's law does or does not apply without modification to all parts of the universe. It is principally in the hope of answering this question that double star observations are carried on, and in the case of the many binary systems already detected, Newton's law is satisfied within the errors of observation. Nevertheless, this evidence is purely negative, and its value, it seems to me, not at all commensurate with the labor expended upon it, unless it be in the case of such objects as Sirius, whose observations may assist in the solution of the problem of irregular so-called proper motion. The angles subtended are in general so small that relatively large personal errors are unavoidable, so that, even though their motions be controlled by a law or laws of gravity widely different from that of Newton, it is not likely that such differences can be proved with any degree of certainty. It is rather to the study of the proper motions of the fixed stars and of the nebulæ, and then only after a lapse of hundreds, and perhaps thousands of years, that we must look for a solution of this question.

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PAPERS READ.

OBLITERATION FROM ILLUMINATION (STELLAR PHOTOMETRY). By HENRY M. PARKHURST, New York, N. Y.

[ABSTRACT.]

IN order to establish the principle that illumination of the field tends to vary the scale of the wedge, I observed Arcturus two hours before sunset with four different apertures differing by half a magnitude. It required about twenty minutes for the approaching twilight to cause the star to become visible with an aperture half a magnitude smaller. It required only four minutes from the first glimpse of the star with each cap for the star to pass entirely across the wedge unextinguished. The effective value of the wedge under that illumination was only about $^{m}.1$, whereas it had been determined to be with a dark sky about $2\,^{m}.3$. Daylight illumination reduced the effect of the wedge in extinguishing stars to less than one-tenth.

The formulæ showing the effect of illumination upon obliteration, applicable to a dark sky, to moonlight, and to twilight, have been deduced by an indirect process, observing the effect of shades. From these formulæ subsidiary tables have been formed, from which it appears that there is a second difference amounting to $^{m}.2$ or $^{m}.3$, resulting from the illumination of the dark sky with a large aperture and low power. For stars always observed at the same point of a wedge this becomes a systematic error. Although needing further verification, the substantial accuracy of these tables has been confirmed.

The ratio of illumination to obliteration has been approximately ascertained, enabling tables for the application of the second differences to be adjusted to different magnifying powers and different apertures.

From observations at different ages of the moon and at different distances from the moon, including observations of Nova Orionis within 2° from the full moon, I have formed tables of the obliteration by the moonlight. From observations in the twilight, I have also formed tables of obliteration from twilight. But there remains to be formed a table from which the combined effect of the two can be ascertained.

Whenever the stars to be observed are sufficiently bright, I prefer to observe them with my deflecting apparatus (described in Vol. XVIII of the Annals of the Harvard Observatory, in a paper just issued) which is unaffected by illumination. But logarithmic caps cut off four-fifths of the light, so that the wedge will measure stars $1^{m}.7$ fainter. If the necessary corrections are applied, the wedge can be used for stars up to the quadrature of the moon and half an hour before the end of twilight, which could not be seen at all with the logarithmic caps.

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A METHOD OF REPRESENTING THE IMAGINARY ELEMENTS OF A GEOMETRIC FIGURE AND OF USING THEM IN CONSTRUCTION. By JAMES MCMAHON, Ithaca, N. Y.

[ABSTRACT.]

1. *Point-graphs.* Call the real points $(a \pm a', b \pm b')$ the *graphs* of the conjugate imaginary points $(a \pm ia', b \pm ib')$. Harmonic properties.

2. *Graph-locus.* If a line meet a conic in two conjugate imaginary points, to find the locus traced by the graphs of these points, as the line moves parallel to itself. To find the real chords joining the imaginary intersections of conics, in certain cases.

3. *Line-graphs.* Call the lines $(l \pm l')\ x + (m \pm m')\ y + (n \pm n') = 0$ the *graphs* of the conjugate imaginary lines $(l \pm il')\ x + (m \pm im')\ y + (n \pm in') = 0$. These two line-pairs have the same angle-bisectors, and are cut by a transversal perpendicular to an angle-bisector in an imaginary point-pair and their real graph-pair.

4. *Orthographs and skew-graphs.* For transversals in a given direction not perpendicular to an angle-bisector, the graph-locus is easily constructed; it is a pair of lines, which may be called the *skew-graphs* for the given transverse direction, to distinguish them from the *orthographs* (for the orthogonal direction). All the graphs for different directions form an involution, of which the imaginary line-pair are the double lines.

5. Given the respective graph-pairs of two imaginary points, not conjugate, to construct (by means of line-graphs) the imaginary line joining them; and reciprocally.

6. Given (by means of graphs) an imaginary line and an imaginary point in it, to construct the imaginary line that passes through the point making a given angle with the first line. Special applications.

ON THE VALUE OF THE SOLAR PARALLAX DEDUCIBLE FROM THE AMERICAN PHOTOGRAPHS OF THE LAST TRANSIT OF VENUS. By Prof. WM. HARKNESS, Washington, D. C.

[ABSTRACT.]

IN this paper an account was given of the instruments and processes employed by the United States Transit of Venus Commission to determine the solar parallax from photographs of the transit of Venus which occurred in December, 1882. Let π be the solar parallax, and δA and δD respectively the corrections to the right ascensions and declinations of Venus given by Hill's tables of that planet. Then, upon the assumption that Hansen's tables of the sun are correct, there resulted from measurements of the distances between the centers of the sun and Venus made upon 1475 photographs, taken respectively at Washington, D. C.; Cedar Keys, Fla.; San Antonio, Tex.; Cerro Roblero, N. M.; Wellington, South

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Africa; Santa Cruz, Patagonia; Santiago, Chili; Auckland, New Zealand; Princeton, N. J.; and the Lick Observatory, Cal.;

$$\pi = 8.847'' \pm 0.012''$$
$$\delta A = + 2.893$$
$$\delta D = + 1.254$$

and the corresponding mean distance from the earth to the sun is 92,885,000 miles, with a probable error of only 125,000 miles.

These numbers are doubtless close approximations to the results which will be obtained from the complete discussion of all the photographs, but they cannot be regarded as final for several reasons, chief among which is the fact that the reduction of the position angles of Venus relatively to the sun's center is still unfinished. It is likely that when these angles are combined with the distances the probable error of the parallax will be somewhat reduced.

The photographs taken at the Lick Observatory seem to indicate that for altitudes four thousand feet above the sea the values of the refraction given by the tables in general use are somewhat too large.

THE DIRECTIONAL THEORY OF SCREWS. By Prof. E. W. HYDE, Station D, Cincinnati, Ohio.

DEFLECTIONS OF THE PLUMB-LINE AND VARIATIONS OF GRAVITY IN THE HAWAIIAN ISLANDS. By ERASMUS D. PRESTON, U. S. C. and G. Survey, Washington, D. C.

ON A NEW METHOD OF CONSTRUCTION FOR EQUATORIAL DOMES. By Prof. G. W. HOUGH, Director Dearborn University, Chicago, Ill.

ON A NEW CATALOGUE OF VARIABLE STARS. By SETH C. CHANDLER, Cambridge, Mass.

A NEW SHORT-PERIOD VARIABLE IN AUTLIA. By Prof. HENRY M. PAUL, U. S. Naval Observatory, Washington, D. C.

LAWS OF FREQUENCY OF ERRORS OF INTERPOLATED LOGARITHMS, ETC., DEPENDENT ON FIRST DIFFERENCES; AND A COMPARISON OF THE THEORETICAL WITH THE ACTUAL DISTRIBUTION OF THE ERRORS OF 1000 INTERPOLATED VALUES. By Prof. R. S. WOODWARD, Geological Survey, Washington, D. C.

SOME CONSIDERATIONS ON THE FUNDAMENTAL IDEAS OF QUATERNIONS. By Prof. E. W. HYDE, Station D, Cincinnati, Ohio.

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A DESIDERATUM IN THE AMERICAN EPHEMERIS. By Prof. GEORGE C. COMSTOCK, Washburn Observatory, Madison, Wis.

FUSIYAMA, JAPAN, AS A SITE FOR A MOUNTAIN OBSERVATORY. By Prof. DAVID P. TODD, Director Lawrence Observatory, Amherst, Mass.

ON THE SUPPOSED CANALS ON THE SURFACE OF THE PLANET MARS. By Prof. ASAPH HALL, U. S. Naval Observatory, Washington, D. C.

NOTE ON THE MATHEMATICS OF THE SEISMOSCOPE. By CLARENCE A. WALDO, Terre Haute, Ind.

ON SOME OLD AND NEW THEOREMS IN SOLID GEOMETRY. By H. B. NEWSON, Mt. Gilead, Ohio.

ORBIT OF BROOKS' COMET, 1888 c. By Prof. LEWIS BOSS, Albany, N. Y.

PRELIMINARY ELEMENTS OF THE ORBIT OF COMETS, 1888 IX. By WILLIAM HOOVER, Athens, Ohio.

ON THE MEASURE OF INCLINATION OF TWO PLANES IN SPACE OF FOUR DIMENSIONS. By Prof. IRVING STRINGHAM, University of California, Berkeley, Cal.

ON CENSUS MAPS. By Dr. FRANZ BOAS, New York, N. Y.

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PHYSICS.

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ADDRESS

BY

PROFESSOR ALBERT A. MICHELSON.

VICE PRESIDENT, SECTION B.

A PLEA FOR LIGHT WAVES.

It is no doubt universally conceded that no era in the world's history has ever seen such immense and rapid strides in the practical applications of science as that in which it is our good fortune to live. Especially true is this of the wonderful achievements in the employment of electricity for almost every imaginable purpose. Hardly a problem suggests itself to the fertile mind of the inventor or investigator without suggesting or demanding the application of electricity to its solution.

Do events in this fast age follow so rapidly that the delays of even the fastest express trains and steamers are unendurable — the remedy is electricity. Is the labor of animals slow and expensive, or the carriage of the motive power itself, as well as its load, dusty, noisy and troublesome — the remedy is electricity. Are the barbarous tallow candle and the almost semi-barbarous use of gas for illumination totally inadequate to bridge over the hours of night — the remedy is electricity.

It would be wearisome to merely mention a tithe of the problems already solved or those on the eve of successful solution — nor is it at all necessary to insist on the richness of the harvest to be gathered by the successful experimenter in this fertile field. Neither is it surprising that so many world-famous men should have de-

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voted almost their whole lives to the pursuit of this most fascinating study.

In the enthusiasm aroused by so many wonderful, beautiful and bewildering results, such varied and far-reaching discoveries in the vast fields of this subtile and powerful agent, it is not to be wondered at—or indeed entirely to be regretted—that possibly a great deal of attention has been diverted from the sister department of light. Undoubtedly, there have been many important developments and improvements in optical instruments — the microscope, the telescope, the spectroscope and the camera may be said to have reached the point of practical perfection — and it is equally true that the observations and discoveries made with the help of these have more than justified the high expectations which their advent created. Certainly the wonderful impulse the study of biology has received by the revelations of the microscope; the enormous increase in our knowledge of the size, distance and motions of the heavenly bodies, due chiefly to the little less than marvellous power and precision of our telescopes; the knowledge of solar and stellar physics — which a few years ago would have been thought visionary if not impossible — attained by the spectroscope, now so happily supplemented by the camera; the insight gained into the structure of matter by spectroscopic interpretation of the messages which its molecules impart to the luminiferous ether,—these are all even more truly wonderful and important than any of the astonishing marvels of electricity. But their original conception belongs to an era that is past.

If we except the exquisite results obtained in the manufacture and use of diffraction gratings and the very important work accomplished by the bolometer (a purely electrical invention, by the way), it may well be questioned whether, within the last twenty years, there has been a single epoch-making discovery or invention either in theoretical optics or in its applications.

It may, perhaps, be argued that the department of optics has been fairly completed; that its theory (though still imperfect in many important points) has been fairly well developed and the range of its applications fairly well understood. The unexpected wonders it has already accomplished make it somewhat hazardous to reply that these same observations may *now* be applied to electricity and magnetism. Still it is safe to say that at any rate the more important facts and laws as well as the more promising lines

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of the development of their applications, are now fairly well known, and that inducements to their further study and development are not wanting.

If, therefore, physicists would devote a larger share of their careful study to the completion of optical theories and to the application of light as an instrument of measurement and investigation—it need never be feared that there would be a lack of electricians to carry forward to their completion, upon lines already well developed, the principles and facts already known.

It is mainly with a view of attempting to interest brother physicists and investigators in this to me most beautiful and fascinating of all branches of physical inquiry that I venture to present a limited number of problems and I think promising fields for investigation in light, together with some crude and tentative suggestions as to their solution.

The investigations here proposed all depend upon the phenomenon of interference of light waves. In a certain sense all light problems may be included in this category, but those to which I wish to draw your attention are specially those in which a series of light waves has been divided into two pencils which reunite in such a way as to produce the well-known phenomenon of interference fringes.

The apparatus by which this is effected is known by the inconvenient and somewhat inappropriate name of "interferential refractometer." Among the many forms of the apparatus several are fairly well adapted to the work they have already accomplished, but all are open to serious objections. In all the forms which employ a broad luminous source of light, the plane in which the interference fringes are most distinct, is found to vary rapidly with slight changes in adjustment; in fact, it may happen that different portions of the same fringe appear at enormously different distances, so that it is impossible to fix the true position of a fringe or even to count the number which pass a given fixed point. This very serious objection is avoided by using, as the source of light, a narrow illuminated slit, but of course at a sacrifice of light and of convenience and simplicity. Both classes of instruments are open to the objection that the two pencils are very close together, rarely more than a centimeter apart. For some purposes this may be an advantage, but for many purposes it is a serious defect. Finally, none of the forms in general use are adapted to experiments in

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which there is a considerable difference in path between the two pencils.

The instrument which I had the honor of describing to the section at the last meeting is free from all the objections mentioned. It is simple in construction; with a little familiarity it is easily adjusted; it may be used with a broad luminous surface; the pencils may be separated as far as desired; and when properly adjusted *the position of the fringes is perfectly definite.*[1] As an additional advantage it may be stated that this is probably the only form of instrument which permits the use of white light (and therefore of the identification of the fringes) without risk of disturbing the position of either surface by contact or close approximation. It is chiefly this property which renders this instrument peculiarly adapted to the comparison of standards of length.

As this form of refractometer has already proved its value in several experiments already completed and in the preliminary work of others now under way, I may be permitted to recall the chief points of its construction and theory. A beam of light falls on the front surface of a plane parallel piece of optical glass at any angle—usually forty-five degrees—part being reflected and part transmitted. The reflected portion is returned by a plane mirror, normal to its path, back through the inclined plate. The second or transmitted portion is also returned by a plane mirror and is in part reflected by the inclined plate, thus coinciding with the transmitted part of the first pencil; and the two pencils are thus brought to "interfere."[2] A little consideration will show that this arrangement is exactly equivalent to an air-film or plate between two plane surfaces. The interference phenomena are therefore the same as for such an air-plate.

If the virtual distance between the plane surfaces is small, white light may be employed and we have then colored fringes like Newton's rings or the colors of a soap-film. If the distance exceeds a few wave lengths, monochromatic light must be employed.

[1] It may incidentally be mentioned that extraneous reflections—such as usually accompany most of the phenomena of interference—may be almost entirely avoided by a transparent film of silver on the front surface of the glass plate where the rays separate; and accordingly the fringes in white light present a purity and gorgeousness of coloration that is only rivaled by the colors of the polariscope.

[2] A second plane parallel plate of the same thickness and inclination is placed (for compensation) in the path of the first pencil.

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We may confine our attention to the case of two parallel surfaces. Here it can readily be shown that the fringes are concentric circles, the common axis of the rings being the normal passing through the optical centre of the eye or telescope. Further they are most distinct when the eye or the telescope is focussed for parallel rays. In any other case we are troubled with the same perplexing changes of form and position of the fringes as already noted.

If now one of the mirrors have a motion normal to its surface the interference rings expand or contract; and by counting the fringes as they appear or disappear in the centre, we have a means of laying off any given distance in wave lengths.

Should this work of connecting the arbitrary standard of length — the yard or the metre — with the unalterable length of a light wave prove as feasible as it is hoped, a next step would be to furnish a standard of mass based upon the same unit. It may seem a little like exaggeration to say that the solution of this problem may admit of almost as high a degree of accuracy as the preceding.

Suppose a cube, ten centimetres on a side, with surfaces as nearly plane and parallel as possible. Next suppose a testing instrument made of two parallel pieces of glass, whose inner surfaces are slightly farther apart than an edge of the cube.

The parallelism and the distance of these surfaces can be verified to a twentieth of a wave. Now apply this testing instrument to the three pairs of surfaces of the cube and determine their form, parallelism and distance to the same degree of accuracy. We have thus the means of measuring the volume of a cubic decimeter with an error less than one part in a million.

A very convenient and accurate method of making the determination of the weight of this volume of water at its maximum density has been suggested by Professor Morley, which consists in making the cube hollow, so that it will have almost exactly the same density as the water. On weighing the cube in water the excess of weight may be as small as required and may be most accurately measured by a very light and sensitive balance.

It does not seem extravagant to say that by some such plan as this we may obtain a standard kilogram which will be related to the standard of length with a degree of approximation far exceeding that of the present standard.

In the manufacture of plane surfaces, the only practicable method

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of testing their accuracy is to place the surface close to a standard plane and examine the appearance of the Newton's rings formed in the air film between them. This process when executed with proper care is undoubtedly the most accurate, and, indeed, is the only one possible for producing a standard surface; but it is attended with a number of inconveniences, among which may be mentioned the use of sodium light, the troublesome reflection from the first surface, the faintness of the fringes when the surface to be tested is metallic and the difficulty of getting rid of dust between the surfaces. All of these inconveniences are avoided by the use of the refractometer. For this purpose the apparatus is placed in a vertical plane, the lower mirror, which would then be horizontal, is replaced, first, by the test plane and then by the surface to be worked. The interference fringes in white light can then be conveniently studied while the surface is being corrected.

Another application of this apparatus, suggested by Professor Morley, is the measurement of coëfficients of expansion. For this purpose a bar is provided with silvered glass mirrors at each end (both facing the same way) and a second bar of the substance to be examined and of the same length is furnished in the same way. These are placed in the refractometer, so that the front mirrors, as well as the rear ones, give interference fringes in white light. The auxiliary bar is kept at zero. The bar to be examined is heated, and the fringes which pass at the front surface are counted as the bar expands, the fixity of the rear mirror being controlled by the colored fringes at its surface. In this method the bars may be a meter in length, and, therefore, the accuracy of the determination would be proportionally greater than in the celebrated experiments of Fizeau, in which the length was limited to a few millimetres.

Evidently the same disposition will also serve for measurements of coëfficients of elasticity, with the evident advantage of studying the elastic properties of the substance in thick rods or bars instead of small wires. This method of investigation is not limited to the determination of changes in length, but is quite as applicable to changes in density and optical properties; particularly to the effect on the velocity of light in solids, liquids and gases due to alterations in temperature, pressure, or magnetic or electrical conditions.

It may be mentioned that a great deal of valuable work has already been accomplished in this direction. I need only cite the

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very interesting and important experiments of Quincke on the compressibility of liquids; of Jamin on the variation of index of refraction of water and of Ketteler and of Mascart on the index of refraction of gases.

It seems somewhat curious that, while the immense advantage of the refractrometer as an accurate means of measuring indices of refraction has been so fully appreciated, its use should be limited to differential measurements. Thus, while it is easy to measure indices of gases, since the difference in optical path for gas and vacuum is so small, the indices of solids and liquids can only be determined in thin plates, and the accuracy of such measurements must be limited to that of the estimation of the thickness. Such experiments may furnish the data for very interesting and important conclusions concerning the index of refraction and specially the anomalous dispersion of intensely opaque substances, such as metals and quasi metallic bodies. In such work the advantage of the interference method over the prismatic must be quite apparent; but I hope to show that for all measurements of refraction and dispersion—for solids and liquids as well as for gases—this method promises results which may far surpass those given by the prism.

Suppose a piece of the substance cut in the form of a plane parallel plate. The accuracy, parallelism and distance of the surfaces in wave lengths may be determined exactly as in the case of the proposed standard cubic decimeter. Next the nearest whole number of waves in the solid can be determined either by actual count or perhaps more conveniently by a method described in a previous paper. The residual fractional parts of a wave may also be found as there described, or by direct observation of the interference rings between the two surfaces.

The measurement of the index of refraction of a liquid is even more simple. A vessel is made with plane parallel sides, and the number of waves between the inner surfaces determined, first, when empty and then when filled with liquid.

The ratio of these two numbers will be the index of refraction. It will be noted that the only observations required in this process are the counting of two numbers; and as Professor Mendenhall has aptly remarked, a mistake in counting of a whole number is not an error but a blunder.

A blunder very easy to make, be it noted, in dealing with such large numbers as two or three hundred thousand, but whose chance

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of occurring may be indefinitely diminished by making several independent observations with different kinds of light.

Perhaps one of the most important applications of the method is the determination of the wave length of standard lines, both relative and absolute. In the paper above referred to, it was stated that the maximum difference of path at which interference fringes are visible, had been increased to over two hundred thousand waves (Fizeau's number is 50,000) by using light from highly rarefied sodium vapor in an exhausted tube. Since then I have observed interference under similar conditions with thallium with a difference of over three hundred and seventy thousand waves, and with mercury, with a difference of more than five hundred and forty thousand waves.

By repeated measurements of the diameters of the interference rings, the fractions of a wave can be found to within a fiftieth—which means that the number of waves in this fixed distance can be found to within less than one part in twenty-five million. Any two kinds of light of this degree of purity can be compared with this same precision. The accuracy of the measurement of absolute wave-lengths will of course depend on the accuracy with which the fixed distance can be compared with the standard meter; and this may be estimated as one part in two million.

The results of the remarkable work of Rowland do not claim a much greater degree of accuracy than one part in half a million for relative determinations; while the elaborate research of Bell on absolute wave-lengths claims but one in two hundred thousand.

We have thus at any rate a very promising method of excelling by far the best results that can possibly be obtained by the most perfect gratings.

It may possibly help to realize the very considerable superiority of this instrument over the grating—at any rate for the class of work in question—if I recall to your attention the fact that by its means it has been possible to show that the red line of hydrogen is a very close double. A short time ago the same was found true of the green thallium line. Both these lines are something like a fiftieth of the distance of the sodium lines, and like these are of unequal intensity. It is even possible to measure this very small interval easily to within a fourth of one per cent. Following are the numbers obtained for the distance from one maximum or minimum of distinctness to the next:—

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Maxima	Minima
1.025	1.012
1.050	1.012
1.025	1.050
1.017	1.033
1.000	1.025
1.038	1.000
1.021	1.017
Mean 1.025	1.021

One unit means a distance of 24.6 mm. which gives for the average distance 25.2 mm. and for the ratio of the wave-lengths of the two lines 1.0000212.

Closely connected with the preceding investigations is the study of the effect of the temperature, thickness, and density of the source on the composition of the radiations, as shown by the symmetrical or unsymmetrical broadening of the spectral lines and the consequent shifting of their mean position. This question has quite recently been taken up by H. Ebert and the results he has already obtained are very promising. The principal effects noted are: first, the shortening of the difference of path at which interference can be observed; secondly, the shifting of the fringes as the mean wave length changes. Ebert has shown that the interference method is far more delicate than the spectroscopic; and by its means he has established two conclusions which, if verified, are of the greatest importance—namely; first, that the chief factor in the broadening of the spectral lines is the increase in density of the radiating body; secondly, that the broadening, in all the cases examined is unsymmetrical—causing a displacement of the line toward the red end of the spectrum. The importance of these conclusions, in their relation to the proper motions of the heavenly bodies and their physical condition, can hardly be overestimated. The value of results of this kind would, however, be much enhanced if it were possible to find a quantitative relation between the density of the radiating substance and the nature of its radiations. In the case of hydrogen enclosed in a vacuum tube this could readily be accomplished. It may, however, be objected that it would be difficult in this case to separate the effects of increased density from those due to the consequent increase in the temperature of the spark. The problem of the temperature of the electric discharge in rarefied gases is one which has not yet been solved. In fact it may seriously be questioned whether in this case temperature has anything to do with the accompanying phenomena of light; and it

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appears to me much more reasonable to suppose that the vibratory motion of the molecules is not produced by collisions at all but rather by the sudden release of tension in the surrounding ether.

Whether true or not, the results obtained and interpreted by this hypothesis would be of great interest. The method could be applied directly to any substance, mercury for instance, for which the relation between the temperature and the pressure is known. For substances for which this relation has not been established, as sodium, thallium, etc., the density may be found by heating the substance in a tube closed with plane parallel glass ends and measuring its index of refraction. The density will be very approximately proportional to the excess of this index over unity.

Aside from its application to this problem, it seems highly probable that this method of measuring the density and pressure of vapors may be made to yield excellent results in cases where these are far too small to be measured directly.

It may not be entirely out of place in this connection to present a few observations concerning the causes of the broadening of the spectral lines. It seems to me that by a thorough and systematic study and discussion of this phenomenon we have a possible means of materially increasing our knowledge of a subject, of which we are at present in almost total ignorance: namely, the real action of the forces and motions of vibrating atoms and of the ether which transmits these vibrations in the form of light.

The possible causes of the broadening of spectral lines are as follows:—

First, the addition of vibrations of periods differing from the normal period, due to the influence of neighboring molecules; secondly, the effect on the wave length due to the velocity of the molecules.

It is evident on considering the second cause, that it could not possibly account for more than a small fraction of the effects observed. For example, to effect a change in wave-length corresponding to the difference between the two sodium lines, would require velocities of the order of three hundred thousand meters per second, over a hundred times as great as the velocities given by the kinetic theory. But it is also clear that when a gas is so rarefied that the first cause cannot possibly produce any perceptible effect, the second cause would be quite sufficient to limit the fineness of the lines, and to impose a definite limit to the difference of path at which interference is visible; and it is worthy of note

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that the actual limits observed are of the same order of magnitude as those given by the kinetic theory.

There is still a third cause which might limit this distance, but which would not have any effect in broadening the lines; namely, the diminution in the amplitude of the vibrations after collision. There must be such a diminution and it would evidently be the more marked the more rapidly the energy was transferred to the ether, that is, the brighter the light. If the effects due to this cause alone could be separated from the others it would be possible to measure the diminution in amplitude and therefore the rate of transference of the energy. Thus it may be shown that a vibrating sodium atom gives up to the surrounding ether less than six millionths of its energy at every oscillation.

Returning to the first and chief cause of broadening, it may be remarked that the universal opinion of scientific men seems to be that during collisions between the molecules the vibrations are entirely "irregular;" and the longer the collisions last in proportion to the time between collisions, the more intense will be the light due to these "irregular" vibrations, and consequently the broader the lines and the more impure the light.

The following consideration would seem to show that this explanation will not hold.

If, in the refractometer, so frequently referred to, white light be used, all phenomena of interference are lost to sight when the difference of path exceeds a few wave lengths, for the well-known reason that the fringes due to the infinite number of different kinds of light are superposed, thus producing a uniform illumination. If now this light be analyzed by a spectroscope, the spectrum will be traversed by well-marked interference fringes which are the finer and closer, the greater the difference of path of the interfering pencils. Now, I have observed such interference fringes in the white light from the incandescent carbons of an arc light when this difference amounted to thirty thousand waves. And it may be added that this limit was reached by the closeness of the lines rather than by their indistinctness.

It seems to me that the only conclusion which can be drawn from this experiment is that in the light from an incandescent solid the vibrations must be *isochronous* for at least thirty thousand waves. The same observation applies also to the so-called "irregular" vibrations of the broadened sodium lines, for the same limit (about thirty thousand waves was also observed in this case). The

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inference seems irresistible that the broadening is not caused by "irregular" vibrations, but by the addition of vibrations whose intensity is greater the nearer their period is to that of the normal vibrations and which may be almost if not quite as regular as the normal vibrations themselves.

If these conclusions be granted we must profoundly modify our conception of radiation in solids and liquids, or at least that part of it which supposes that such radiation produces a continuous spectrum because the molecules have no "free path," and, therefore, no proper periodic vibrations.

What, then, is the nature of the effect produced by the collision of molecules? If it be to produce or reinforce vibrations differing from the normal type, it must be granted that these new vibrations are *isochronous*. If so, they must be due either to a change in the form or in the mass of the molecule itself produced by collision, such changes tending to revert back to the type when the frequency of the collisions is not too great. The only alternative is to suppose that the molecules differ among themselves, either in form or weight. In this case, the molecules agreeing most nearly with the type and hence having a proper period differing but little from the normal would be more easily set in vibration than the others, or their vibrations once started would outlast the others. Accordingly, when a gas is very much rarefied, the collisions are few, hence only the typical vibrations persist; but when the collisions are frequent the other vibrations are also sustained.

I fear I have wandered so far from the subject of this address, if such a name be at all appropriate, ever to return; and, though many other interesting and important applications of light-waves clamor for recognition, I fear they would be wearisome even to enumerate.

I fear also that it may with some justice be said that I have made a plea for my own instruments and theories, rather than "a plea for light waves;" and still more that I have presented many crude and half digested ideas, when it would have been more to the purpose to present facts and results of diligent study and careful experiment.

In extenuation and in conclusion I can only hope that if I have created the slightest interest in the matters here presented for your consideration, if there be any chance that even a few of the seeds may germinate, grow, blossom and bring forth fruit worthy of acceptance, my purpose will be accomplished.

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PAPERS READ.

ON THE DIFFUSION OF HEAT IN HOMOGENEOUS RECTANGULAR MASSES, WITH SPECIAL REFERENCE TO BARS USED AS STANDARDS OF LENGTH. By R. S. WOODWARD, U. S. Geological Survey, Washington, D. C.

[ABSTRACT.[1]]

THIS paper discusses the laws of diffusion of heat in rectangular masses of any dimensions, and aims to give to the various problems that arise, solutions which may be readily used in computing numerical results.

The assumptions on which the work is based are the following: (1) that the mass has initially a uniform temperature; (2) that it cools or heats in a medium of sensibly constant temperature; (3) that the exterior and interior conductivity and thermal capacity of the mass remain constant.

Starting from Fourier's solution of the general problem defined above, the obstacles met in applying that solution are pointed out. Fourier's method requires a certain number of the roots of the three transcendental equations which express the boundary conditions of the mass. The new solution either avoids the difficulty of determining those roots altogether, or makes use of the first root only of each equation. Incidentally, however, methods of computing the roots are given.

The pervading idea of the investigation is this, viz.: to separate the terms independent of from those dependent on the exterior conductivity, or emissivity. In accordance with this idea, the problem divides itself into two cases, in the first of which the ratio formed by the product of the emissivity and a linear dimension of the mass is less than unity, and in the second of which that ratio is greater than unity.

Formulas for certain average temperatures of special interest relative to standards of length are given, viz.: the average temperature of the whole mass, of any face and of the axis of a bar.

Special attention is given to the needs of the computer in the derivation and arrangement of formulas, and the application of nearly every formula is illustrated by a numerical example.

[1] The paper will be published in full in Annals of Mathematics, Vol. 4, No. 4.

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A NOTE UPON RETINAL PHOTOGRAPHY. By CHARLES A. OLIVER, M.D., 1507 Locust St., Philadelphia, Pa.

[ABSTRACT.]

In a desire to place upon record the author's progress in this direction, he would state that at the present writing (July, 1888) he, in conjunction with Dr. Wharton Sinkler, has obtained a fixed and easily adjusted apparatus consisting of an ophthalmoscopic attachment to a small field camera that can be adjusted to any position, a boxed oil light so arranged that the emergent rays pass through a two inch focus biconvex lens before becoming impinged upon the ophthalmoscopic mirror, a small fixed headrest for the subject, and a spectacle frame lens attachment to be placed before the subject's eye. The experiments, which were at first conducted with the artificial eye of Perrin and which resulted in negatives with clearly cut discs of about twenty-five millimetres in their long diameter, surrounded by an area of one hundred millimetres upon which the retinal vessels and gross changes in the retina and chorold could be plainly seen for nearly seventy-five millimetres area around the disc, the whole being entirely devoid of any disturbing light reflexes (these were untouched and unremagnified), have now been transferred to studies with the living human eye. Here the only difficulties have been the interfering corneal reflex and the heat experienced. The latter has been successfully combatted by resource to Dr. Howe's alum bath, while the former is the part of the subject now under experiment. The entire method with a full description of the completed apparatus will be published as soon as obtained.

THE QUALITY OF MUSICAL SOUNDS. By W. LECONTE STEVENS, Brooklyn, N. Y.

[ABSTRACT.]

In this paper a brief sketch is given of the method adopted by Helmholtz in his investigation on musical quality, which resulted in the conclusion that "differences in musical quality of tone depend solely on the presence and strength of partial tones, and in no respect on the differences of phase under which these partial tones enter into composition."

A résumé is given of a paper on the "Beats of Imperfect Harmonies," read by Sir William Thomson in 1878 before the Royal Society of Edinburgh, in which he expresses conclusions inconsistent with those previously reached by Helmholtz.

A description is then given of the wave siren invented by Rudolph Koenig of Paris, for the purpose of testing the effect of change of phase on quality of tone. This instrument was brought to America a few years ago,

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but was injured in transit so that it could not be operated. It has since been further improved. The writer has had an opportunity to test its action in company with M. Koenig, and believes that through this instrument the truth has been established, that variation in phase among the components of a compound sound is a distinct element in determining musical quality. Helmholtz's view is that generally found in text-books.

ON DYNAMICAL UNITS. By Prof. T. C. MENDENHALL, President of Rose Polytechnic Institute, Terre Haute, Ind.

[ABSTRACT.]

CONFUSION exists in the use of the terms *weight* and *mass*, much of which arises out of the use of the word *pound* in two senses. It is generally and properly used both as a unit of mass and as a unit of force. This fact should be clearly recognized in text-books of engineering and it is desirable that the pound as a unit of force should be accurately defined. The definition suggested is that it is the force of attraction between the unit of mass called a pound and the earth. Dynamical equations should be freed from "g" (gravity), the units being poundals, if force, or foot-poundals if work. These can afterward be units reduced to the more common gravitation units if desired.

PROTECTION OF WATCHES AGAINST MAGNETISM. By C. J. H. WOODBURY, Boston, Mass.

[ABSTRACT.]

THE growing and even general use of electricity for illumination and for the transmission of power has added much to the knowledge of electrical phenomena, and also called the general attention of the public to matters long known to those familiar with physical science.

Public attention was first called to the influence of magnetism on watches at the Paris Electrical Exposition, where visitors could leave their watches near the entrance.

My first experience with the effects of electricity on a watch were decidedly unpleasant; for I was struck by lightning in July, 1881, at a time when I was thoroughly drenched with water. The only permanent damage was received by my watch, which was marked on the back of the case with two straight black stripes, each about half an inch in width, extending across the back and joined together at one end like a letter V. Three of the arbors in the movement were broken, but there was no discoloration except on the outside.

Another watch, which possessed a remarkably uniform rate and was highly valued for its accuracy, yielded to the temptation offered by the

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magnetic fields around dynamos and became very uncertain, losing time at irregular intervals and at varying rates.

The usual methods of demagnetization were all tried with the result of lessening the evil, but not removing it, as it seemed to be impossible to bring back the movement to the old rate.

It is surprising how weak a magnetic field will stop a watch, a small magnet being sufficient for the purpose; and far weaker magnetic fields will interfere with the rate of a watch to an extent which will injure its value as a timepiece.

There are two types of attachments designed to protect watches against magnetism; one being a small disc of iron taking the place of the inner cover of a watch case; and the other a box or case surrounding the watch case, like the outer case of a bull's eye watch. Without endorsing any of the extreme statements declared to be fundamental principles of magnetism by those engaged in the sale of either of these devices, it is evident that any magnetic body will distort lines of force in a magnetic field; and it was considered worth while first to submit the metal case to direct experiment.

The magnet used was a small dynamo containing cast iron to the weight of about four hundred and fifty pounds. The armature was disconnected from the apparatus and the field coils connected to an electric circuit, in order that the watches should not be subjected to jar from a revolving armature.

A circular piece of cardboard was placed in the case and dusted over with iron filings which had not been magnetized, and the box was closed and placed on a block of wood a foot from one of the poles of the magnet.

An electric current sufficient to saturate the magnet passed through the field coils for a few moments, and the circuit was broken before the case was opened in order that the contents should not be directly exposed to any attraction except what was transmitted through the iron forming the case. On opening the case it was seen that the iron filings had been drawn towards one side of the card and arranged in striæ in the ordinary manner whenever they are exposed to a magnetic field.

A watch which had been set to exact time with one in an extreme part of the room was placed in the case, and in a like manner exposed to the magnetic field for five minutes. When the case was opened it was found that the watch had stopped at the instant that the magnet was charged; and the movement has been magnetized to an extent which has robbed it of any present value as an accurate timepiece.

As it was evident that the case did not adequately protect the watch, experiments were not made with the shield referred to, which contained a small fraction, perhaps one-tenth, as much metal as the case.

These watches were not exposed to any more severe tests of magnetism than would be liable to be offered to a watch worn on the person of one around a dynamo or motor, except that a passenger in a motor car would naturally be in a sitting position and the watch would be exposed for a longer time to any lines of force than would be the case around a dynamo,

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where the person would not probably remain in a stationary position so long a time.

Some time ago I examined a watch containing the inventions of C. A. Paillard, of Geneva, in which the hair spring and balance were made of alloys of palladium, the escapement being made of steel, and found that although a weak magnetic field did not produce any apparent effect upon the movement, yet it was stopped by exposure to a very strong attraction.

This difficulty would be intermittent in its nature even under the extreme conditions of magnetic force which stopped the watch, because the balance and hair spring were composed of non-magnetic alloys.

Subsequently, when the same make of watches were produced containing the whole escapement as well as balance and hair spring composed of alloys of palladium, I exposed one to the tests mentioned above without stopping it or interfering with its rate.

It is probable that long continued exposure to an intense magnetic field would tend to accelerate the rate of such a watch, because the resistance to cutting the lines of force would slightly reduce the length of the arc of vibration and therefore increase the number of beats during a given time; but I have not had time to learn by experiment whether these conditions of continuous exposure to an intense magnetic field could under any circumstances affect the rate of such a watch. It is evident, however, that a watch worn on the person would not be exposed for a sufficient length of time to receive any modification of rate. In any event, such influence upon rate would not be permanent, but would continue only while the rapidly moving parts were cutting lines of force in a magnetic field.

The alloys of palladium referred to possess an elasticity comparable to steel, as is shown by their practical operations in watches and chronometers. It is undoubtedly not oxidizable in moist air; and the alloys, being composed of both paramagnetic and diamagnetic metals, must approximate more or less closely to a neutral substance.

Several of the types of watches made in this country and in Europe have contained non-magnetic movements, using alloys of other metals than palladium.

The present extensive use of dynamos, and the prospective general introduction of motors, especially upon street railways, will render watches which are unaffected by magnetism a general necessity to all desiring accuracy in their watches.

SOME PHOTOGRAPHIC EXPERIMENTS ON THE COLOR OF THE SKY. By Prof. FRANK P. WHITMAN, Adelbert College, Cleveland, Ohio.

[ABSTRACT.]

LORD RAYLEIGH, in discussion of Tyndall's theory of the color of the sky, showed that the scattering of light from small particles is sufficient to explain most of the phenomena connected with skylight, especially its color and polarization. His experiments on the subject seemed to substantiate the theory.

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In 1879 O. E. Meyer found that diffused daylight, which is practically skylight, showed in comparison with direct sunlight a preponderance not of the shorter, but of the longer wave-lengths, making daylight reddish relatively to sunlight.

Prof. E. L. Nichols, in 1885, found skylight to differ on the whole from white light less than that reflected from most white substances, so called. He made the hypothesis that the blue of the sky is mainly subjective, due to the well-known sensitiveness of the eye to short wave-lengths under faint illumination.

The author has attempted to bring these conflicting results to a definite, though qualitative test, by means of photography, thus avoiding complications arising from peculiarities in the eye.

The ordinary gelatino-bromide plate is chiefly sensitive to the shorter wave-lengths. If it be bathed in a solution of erythrosine and exposed in the camera behind a yellow screen, the greatest sensitiveness will be found, not in the blue, but in the yellow.

Suppose two objects, one blue, the other white, but of such brightness that both send the same amount of blue light to the camera. If they are photographed in the same field, the images will appear on the blue-sensitive plate of equal intensity, while on the yellow-sensitive plate the white object will make the stronger impression.

Various white objects illuminated by the sun were photographed against a blue sky on these two kinds of plates. More than thirty photographs were taken of the moon in full daylight. Six were made from a block of magnesium carbonate. White clouds were photographed in a blue sky and landscapes photographed in which a blue haze obscured the distance.

All these experiments led to similar results. The object photographed on the blue-sensitive plate was faint, or hardly distinguishable from the background of the sky, while on the yellow-sensitive plate the image was clear and strong.

The results seem to prove conclusively that the light from the sky is distinctly blue, and, as far as they go, to uphold the theory and experiments of Tyndall and Rayleigh.

ON A METHOD OF DETERMINING THE EMISSIVITY OF A METALLIC BAR COOLING OR HEATING IN AIR. By R. S. WOODWARD, Geological Survey, Washington, D. C.

[ABSTRACT.]

THIS paper shows how from observations of the varying temperature or length of a bar, cooling or heating from an initial uniform temperature in air of constant temperature, the emissivity or surface conductivity may be found in terms of the thermal capacity of the bar. The theory of the process is derived from the last section of the author's paper "On the Diffusion of Heat in Homogeneous Rectangular Masses." The results found by applying the process to certain experimental data are stated.

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ON AN EXPERIMENT BEARING UPON THE QUESTION OF THE DIRECTION AND VELOCITY OF THE ELECTRIC CURRENT. By Dr. E. L. NICHOLS of Ithaca, N. Y., and WILLIAM S. FRANKLIN of Lawrence, Kansas.

[ABSTRACT.]

A COIL of wire of 390 turns was driven at a very high rate of speed, the axis of the coil being the axis of rotation. When the coil reached 380 revolutions per second, the linear velocity of the wire in the direction of its own length amounted to 8,000 centimeters per second. By means of two brush contacts at the axis a current was sent through the coil while the latter was in motion. The magnetic moment of the coil was determined by means of a very sensitive astatic pair of magnets carrying a mirror.

Readings were taken with the coil at rest and in revolution, the motion of the coil and the direction of the current being repeatedly reversed. If the electric current result from the flow of a fluid through the wire, in other words, if it may be considered as possessing direction and finite velocity, a motion of the conductor, with or against the current, should produce an appreciable influence upon the deflection of a magnet needle, even though the velocity of the current were very large as compared with that of the conductor. In order to render the detection of this presumably very small effect less difficult, the direct influence of the coil was eliminated by differential winding. Under these circumstances, when the coil was carrying as large a current as it could be made to do without injurious heating, the rotation of the coil was found to be without appreciable effect upon the magnetic moment of the same.

The best results were obtained by sending 4.6 amperes of alternating current of 40,000 alternations per minute through the coil. At a velocity of the wire equal to 8,000 centimeters per second the rotation of the coil produced no effect upon the needle amounting to 0.2 millimeters deflection. The figure of merit of the coil and needle was determined by substituting a coil of continuous winding, its position with respect to the needle being the same as that of the rotating coil, and determining the current necessary to produce 1 centimeter deflection. The sensitiveness of the apparatus was found to be such that a current having direction and a velocity of 1,000,000,000 meters per second would have shown a change in its action upon the needle (when the motion of the coil was 380 revolutions, 8,000 centimeters per second) amounting to 0.1 centimeter deflection, an effect which could not have escaped observation. It follows from the above negative results that if the electric current consists in the flow of a medium or fluid through the conductor, the velocity of the same must be greater than the exceedingly high rate just mentioned. Foepl, who in some recent experiments (Wiedemann's Annalen, 1886), used an apparatus in most essential particulars similar to our own, but one by means of which only relatively very low velocities could have been detected, has reached the same negative conclusion.

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ON THE EFFECT OF THE ADDED TERM OF THE EQUATION OF THE QUADRANT ELECTROMETER ON ITS DEFLECTION CURVES. By Prof. T C. MENDENHALL, President of Rose Polytechnic Institute, Terre Haute. Indiana.

[ABSTRACT.]

To the well known expression for the momēnt of the couple acting on the needle of the quadrant electrometer, M. Gouy has added a term depending on the difference of potential between the two quadrants and proportional to the square of this difference. The effect of this term on the deflection curves of the electrometer, as mounted according to Mascart, Thomson or Joubert, is investigated and found to be essentially as follows:—The Mascart equation still remains that of a straight line; the Thomson method reduces the equation to one of the third degree, no longer representing a parabola, but a curve with two branches, each having a point of inflection and an asymptote common to both. It is also shown that the first part of this may be assumed to be a straight line without sensible error, provided the potential of the needle is very large compared with that of the quadrants; thus, if the needle is charged to 5,000 volts, potentials below 100 volts may be compared by this method with less than one per cent error. . . . By the Joubert method of mounting, in which the needle and one quadrant are connected and the other is put to earth, the equation, which without the added term represents a common parabola with the origin at its vertex, is that of a curve somewhat similar to a parabola but with a point of inflection in each branch and an asymptote common to both branches.

INCANDESCENT LAMPS CONSIDERED AS MACHINES FOR TRANSFORMING ELECTRICAL ENERGY INTO THE ENERGY OF LIGHT. By ERNEST MERRITT, Ithaca, N. Y.

[ABSTRACT.]

THE author determined the ratio of the energy of the visible rays to the total energy of the lamp. This was done by cutting off the dark heat by a cell of about one decimeter thick, containing a solution of alum, and allowing the rays transmitted to fall on a delicate thermopile. The deflection of the galvanometer in circuit with the pile was then proportional to the energy of the light from the lamp. The alum cell was then removed, and the deflection corresponding to total radiation observed. The ratio of the two deflections gave the efficiency of the lamp at that candle power, when considered as a machine for producing luminous rays.

This ratio was determined in one case by placing the lamp to be tested in a large glass calorimeter and measuring the heat given to the water and the total electrical energy supplied. In both cases corrections were applied, due to the fact that water or alum does not absorb quite all of the

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dark heat. In the case of alum this transmission amounts, in extreme cases, to 0.5 per cent. With water it is about 1.5 per cent. A correction was also made for the absorption of light by the water.

The results show that the efficiency of a lamp as a machine does not correspond at all with its commercial efficiency.

One lamp may have a larger "luminous efficiency" than another, and yet require a much larger expenditure of energy to bring it to the same candle power. For example, two Edison lamps were tested: one being quite new, the other old and commercially inefficient. The first gave 16 C. P. at 85 Watts, with a "luminous efficiency" of 4.0 per cent; the second gave 16 C. P. at 100 Watts, with an efficiency of 7.4 per cent.

The values of the "luminous efficiency" of five different lamps at different candle powers are given below in per cents:

	1 C. P.	2 C. P.	4 C. P.	8 C. P.	16 C. P.
Edison, 108 volt, new,	0.6	0.7	1.1	2.2	4.0
Edison, 100 volt, old,	2.3	3.2	4.7	6.3	7.4
Weston, 110 volt,	2.9	3.5	4.1	5.7	
Weston, 70 volt,	2.4	2.9	3.6	4.8	
Bernstein, 20 volt, 8 C. P.,	1.6	2.5	3.7		

The energy per candle power was also calculated from these results. This energy, or the mechanical equivalent of one candle power, decreases as the candle power rises.

The following table gives the values of this mechanical equivalent in Watts:

	1 C. P.	2 C. P.	4 C. P.	8 C. P.	16 C. P.
Edison, 108 volt, new,	0.58	0.30	0.17	0.17	0.20
Edison, 100 volt, old,	.85	.80	.73	.64	.47
Weston, 110 volt,	.84	.68	.51	.37	
Weston, 70 volt,	.75	.57	.42	.37	
Bernstein, 20 volt, 8 C. P.,	.61	.54	.51		

FLOATING DYNAMOMETER. By Prof. J. BURKITT WEBB, Stevens Institute, Hoboken, N. J.

[ABSTRACT.]

AT last year's meeting a new form of dynamometer was described with the aid of an illustrative model, which was more however in the form of a laboratory experiment than in that of practical application. During the past year two practical dynamometers have been constructed and have worked satisfactorily in all respects, so that there would seem to be no better method of testing dynamos and motors, especially those of great weight or unsymmetrical form. Especial forms have been devised for other purposes among which is a floating transmission dynamometer capable of giving exact results for scientific purposes.

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The photographs show an eight-hundred pound dynamometer mounted with a "Westinghouse Exciter" of nearly that weight.

The "Ark," or "Floating Dynamometer," is applicable to all cases where a "Bracket Cradle" might be used and possesses some advantages which the latter has not.

"OVERHAULING" IN A MECHANICAL POWER. By Prof. J. BURKITT WEBB, Stevens Institute, Hoboken, N. J.

[ABSTRACT.]

PROFESSOR BALL, in his book on "Experimental Mechanics," has attempted to state a general law for such "overhauling." His statement is that whenever rather more than half of applied energy is lost in friction the apparatus will not overhaul.

It has been shown by others that this statement is not always correct[1], though the entire fallacy of it may not have been perceived, the law, as we have worked it out, not having such a simple expression.

We will simply show here how a mechanical power may be constructed which will not overhaul and yet lose much less than half the applied energy in friction.

For example let the "power" be a simple lever with the power pulling upward and the weight consequently applied between the power and the fulcrum. Let the weight be applied at one inch and the power at two inches from the fulcrum and let the latter be a journal having a radius of five inches turning in a suitable box or bearing with a friction of one-fifth of the weight; *i. e.*, with a coëfficient of friction equal to the tangent of the angle whose sine is one-fifth. Such a mechanical power will not overhaul and will waste in friction but one-quarter of the energy applied.

This may suggest to any one having the necessary mechanical insight how to construct other non-overhauling mechanisms with other fractions of energy lost in friction.

IMPACT IN THE INJECTOR. By Prof. J. BURKITT WEBB, Stevens Institute, Hoboken, N. J.

[ABSTRACT.]

SOME comparisons have been made between pumps and injectors as to the mechanical work performed by them respectively in feeding a boiler; it is thus brought out very forcibly that while the injector wastes no energy it does very little work, most of the steam being used in warming the water. It will be interesting to notice the reason for this because it depends upon the simple principles of mechanics, which though embodied in the usual equations for the injector may not, in that form, be sufficiently appreciated.

[1] Dr. Coleman Sellers, of Stevens Institute, Hoboken, N. J., showed this in a lecture to the upper classes so far as applied to an apparatus consisting of a number of parts.

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There are three places in the injector to which we will call attention in examining the action of a particle of steam; (*a*) in the boiler, (*b*) in the vacuum chamber, (*c*) in the mixed column of water and steam. At *a* the steam is practically in a state of rest, but possesses energy capable of doing work. In passing from *a* to *b* work is done in giving to the steam a high velocity, so that at *b* it possesses a large portion of kinetic energy by virtue of which it strikes the water a blow and sets it in motion. Suppose now that the steam, having a velocity v, strikes, say, fifteen times its mass of water and sets it in motion, the combined mass will have a velocity of only one-sixteenth of v, because the momentum before impact, $v \times 1$, must be equal to that after impact, $v \div 16 \times (1 + 15)$.

The kinetic energy possessed by the steam before impact is equal to $\frac{1}{2} \times v^2$ but afterward there will be no more then $\frac{1+15}{2} \times \frac{v^2}{16^2}$, so that at impact fifteen-sixteenths of the kinetic energy of the steam disappears, being retransformed into heat by the concussion, it will thus be seen that the injector does primarily transform a large amount of heat into work, but that it uses this work in so uneconomical a way, in forcing the water into the boiler by impact, that most of it is wasted as mechanical work, though saved as heat.

NOVEL FORM OF ELECTRO-MAGNETIC TELEPHONE. By Prof. R. B. FULTON, University, Mississippi.

[ABSTRACT.]

THE author has devised a form of electro-magnetic telephone, which may be used as a receiver or transmitter, in which the lines of magnetic force, the direction of the induced currents, and the direction of the movement of the vibrating parts are each at right angles to the other two. This end is attained by dispensing with the ordinary spool electro-magnet and circular diaphragm.

A tube of thin sheet iron, open at one or both ends, having a polygonal cross section, is magnetized, and has ordinary fine insulated telpehone wire coiled around the outside, the coils being each in a plane perpendicular to the length of the tube. One end of the tube is made a north, and the other a south pole. The coils are placed over those parts of the walls of the tube which are thrown into vibration when the tube is spoken into. The best results seem to be obtained with the above instrument as a transmitter, and the ordinary Bell receiver.

A NEW PRESSURE INDICATOR OR RECORDER (EXPERIMENTAL MODEL). By Prof. W. H. BRISTOL, Stevens Institute, Hoboken, N. J.

[ABSTRACT.]

IN this instrument the novelty consists in employing a special form of the well-known Bourdon spring tube in combination with a principle involved in the construction of a pressure indicator which was invented and

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patented by Jno. Matthews in 1855. With such a combination it was found to be possible to produce a pressure indicator in which the movement of the registering pointer is positive and of such range for given variations that the usual or all multiplying devices may be dispensed with. The invention of Matthews consisted in making a tube of copper by electric deposition, of circular cross section with one side corrugated. One end being closed, an internal pressure produced an elongation of the corrugated side which, being restrained by the straight side resulted in a bending of the tube, the amount of bending depending upon the pressure. The deflections produced as described are then multiplied to suit the range of reading required.

In the self-registering instrument exhibited the tube has a flattened cross section, is closed at one end, and bent into an approximately sinusoidal form. At several points along its length is secured a flexible strip of same metal as tube or of one having the same coëfficient of expansion.

The bent tube may be considered as a series of Bourdon springs placed end to end. If the bends are of equal radii of curvature, an internal pressure would produce a tendency to straighten each, or collectively to elongate the whole. This elongation is restrained and converted into a magnified lateral motion by means of the flexible strip. If the bends on one side of the tube are of greater radius than those on the other, the motion due an internal pressure will be the resultant of an elongation and a lateral deflection, the lateral deflection being due to the difference in the sums of the forces tending to straighten the bends on the opposite sides of the tube. When the flexible strip is applied to the side of the tube with the larger bends restraining the component of elongation, an increased side deflection is produced.

By mounting such a tube with a marking point attached in connection with a uniformly moving chart, an extremely simple and reliable recording pressure indicator may be devised.

The sensitiveness of the tube may be varied by changing proportions and making different combinations of cross sections, thickness of walls, radii of curvature of bends, number of bends, and length of tube. The same form of instrument is adapted for use as vacuum as well as for pressure indicators.

A NEW INDICATING OR SELF-REGISTERING THERMOMETER (EXPERIMENTAL MODEL). By Prof. W. H. BRISTOL, Stevens Institute, Hoboken, N. J.

[ABSTRACT.]

THE pressure indicator described in the preceding paper is filled with an expansible liquid, as alcohol, and permanently sealed.

Variations in temperature produce expansion of inclosed liquid causing internal pressure, which in turn gives deflections corresponding.

With marking point and chart for recording deflections, a simple self-registering thermometer may be constructed.

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A NEW INDICATING OR SELF-REGISTERING BAROMETER (EXPERIMENTAL MODEL). By Prof. W. H. BRISTOL, Stevens Institute, Hoboken, N. J.

[ABSTRACT.]

THIS instrument is an application of the pressure indicator already described. A tube, made by electric deposition, is exhausted of air and sealed. The walls of the tube being sufficiently light, it is sensitive to small changes of external pressure: as, for instance, atmospheric changes.

For a self-registering instrument it would only be necessary to mount such a tube, with its marking point, in conjunction with a moving chart for receiving the record.

BEST METHODS OF MAKING INSTANTANEOUS PHOTOGRAPHS DURING BOTH DAY AND NIGHT. ILLUSTRATED BY EXPERIMENTS AND PROJECTIONS. By Dr. E. P. HOWLAND, Washington, D. C.

[ABSTRACT.[1]]

INSTANTANEOUS photography by the discovery and introduction of dry plates has given a great impetus to science in every department. It is now necessary that investigators in most branches of science should have a practical knowledge of the art. It records his discoveries by a process of Nature's engraving that is absolute truth. Any advancement in this art by discovery or application interests all investigators. In a condensed form, I will state some of the most important facts in relation to this subject and exhibit specimens of actual results.

The best lens for taking instantaneous photographs of landscapes and moving objects at a distance of one hundred feet and over is a single achromatic lens with the largest diaphragm that will give good definition, a single achromatic obstructing less light than a double achromatic lens with the same sized diaphragm and equal focus. As a single achromatic cannot be used for near objects, on account of distortion of the image, a double achromatic lens is absolutely necessary with the largest diaphragm that gives good definition. Magnesium in powder with any substance that will cause a rapid combustion is the best substance known for producing a light for instantaneous photography in dark rooms or at night. Chlorate of potash, sulphur, guncotton, sulphide of antimony, picric acid and other substances can be used with the magnesium; but I prefer magnesium with one-third its weight of flour of sulphur. This has given me satisfaction, is a safe compound to use and can be ignited by any burning substance or the electric spark. With the camera six feet from the object and the flash light two feet back and a little to one side of the camera, thirty grains of magnesium and ten grains of sulphur with a reflector behind the flash, will give a good photograph on an ordinary plate of No. 25

[1] This paper was accompanied by an exhibition on the screen of the photographs alluded to.

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sensitometer or an orthochromatic plate No. 27. At twelve feet distant, one hundred twenty grains of magnesium and forty grains of sulphur are required. Good photographs can be taken on a 25 sensitometer plate at the distance of twenty-four feet by flashing four hundred and eighty grains of magnesium and one hundred and sixty grains of sulphur. On a 35 sensitometer plate one-half of this quantity is sufficient.

At a distance of six feet, this flash light, I find, is equal in its actinic effects on the plate to the ordinary ribbon magnesium lamp running thirty seconds, with a ribbon one-eighth of an inch in width and burning twelve inches of ribbon.

At twelve feet distance of camera, the flash light is equal to the exposure with magnesium lamp of two minutes and burning four feet of ribbon.

At greater distances than twelve feet my experiments of comparison are indefinite. If a white screen is placed on one side of the object, opposite the side on which the flash is made and a white screen or mirror behind the flash, the illumination is improved and the shadow is less dense. The same result can be obtained by having on the other side of the camera fifteen grains of magnesium with five grains of sulphur and igniting them both at the same time by a spark from a small Ruhmkorff coil. An intervening screen of translucent cloth or paper or ground glass between the the flash and object, will also give fine results but more magnesium is required to be burned as some of the light is obstructed. Exposures by day, when the time is less than one-tenth of a second, should be made from 11 A. M. to 2 P. M. in clear sunshine. The sensitive plate used for instantaneous work should not be less than 25 sensitometer and fewer failures will be made with number 30 or 35. One of the photographs that I will show you is a street view and U. S. Custom House in Charleston, that I took after the earthquake at 12 M., on Sept. 16, 1886, on a 25 sensitometer plate with a single achromatic lens and $\frac{f}{15}$ diaphragm, clear sunshine, estimated time $\frac{1}{20}$ of a second, using a metal drop shutter. Another photograph is a street scene in Washington, corner 4½ Street and Pennsylvania Ave., taken at 1 P. M., July 10, 1887, on a 35 sensitometer plate with a double achromatic lens, $\frac{f}{12}$ diaphragm, clear sunshine, time $\frac{1}{200}$ of a second, using a Prosch shutter. The moving objects in this photograph appear as if at rest in the attitudes seen. Another photograph is one that I took of a snow scene in Washington, corner of 7th and Pennsylvania avenue, at 11 A. M. April 1, 1887, on a 25 sensitometer plate, with single achromatic lens and $\frac{f}{15}$ diaphragm; thin clouds and snowing slightly, estimated time $\frac{1}{40}$ of a second, using a drop shutter with rubber band accelerator.

The shorter the time in which a photograph of moving objects is taken when a good impression can be obtained on a plate the more perfect the photograph. Professor Maybridge has taken photographs of moving objects in the $\frac{1}{5000}$ part of a second.

Distance and velocity of moving objects must be taken into account in successful instantaneous photography. With a lens of five-inch focus and object 1,000 feet distant moving at ten miles per hour, the image on the sensitive plate will change $\frac{73}{100}$ of an inch in one second. A railroad train, moving at

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the rate of forty miles an hour, at the distance of four hundred feet, or a man walking two and one-half miles per hour, at twenty-five feet distant, will change the image on the plate the same amount in the same time. The change of over one-half an inch in the image will make a mixed blur of objects, but if the time is reduced to the $\frac{1}{200}$ of a second, the image will then only change the .0036 of an inch, and this change of less than the .0004 of an inch will give a distinct image. The actual motion of a railroad train at forty miles per hour is fifty-eight feet and eight inches per second. A street car at ten miles per hour is fourteen feet and eight inches and a man walking at the rate of two and one-half miles per hour is three feet and eight inches per second.

The method of calculating the change of image on the plate is the same as the lever; the long arm being the distance from the moving object to the lens and the short arm the focus of the lens.

The photograph of a lightning flash can be taken at night by adjusting the camera for distant objects by daylight and then at night pointing the camera with the cap off toward the thunder cloud and await the flash. A single achromatic lens is the best to use. A good photograph of a lightning flash that I will show you was taken by Prof. C. F. Marvin of the U. S. Signal Office, June 19, 1887, at 3 A. M., taken on a Carbutt plate, No. 24 sensitometer, with double achromatic lens, 10-inch focus, $\frac{f}{10}$ diaphragm. The camera was left open four minutes during which time several successive perpendicular and horizontal flashes were photographed on the plate. The exposure was made in Washington, corner of 13th and S streets, N. W. The building photographed on the plate by the lightning flash is Howard University. Good photographs can be taken of the sparks from an induction machine having quart jars in connection with the prime conductors and using a short focus lens.

The photographs exhibited in rapid succession were taken by myself with a 5-inch focus lens and $\frac{f}{6}$ diaphragm on a 35-sensitometer plate.

One photograph sent me from the U. S. training school at Willett's Point, New York harbor, is that of a mule with his head blown off with a dynamite cartridge and photographed before falling to the earth. Taken with a 16-inch focus lens, $\frac{f}{32}$ diaphragm, on an Eastman plate, sensitometer 22, 2 P. M., sunshine and light clouds. Another photograph taken by Prof. C. W. Smiley of the National Museum, Washington, is a mackerel schooner under full sail, taken from the deck of a steamer going in the opposite direction. Lens 16¼-inch focus, diaphragm $\frac{f}{16}$, exposure $\frac{1}{100}$ of a second, plate sensitometer 25, sunshine, 12 M. A photograph of base ball playing, showing balls in the air, was taken by Mr. C. C. Jones, assistant photographer U. S. surveys, with a detective camera of 6-inch focus, diaphragm $\frac{f}{24}$ at 4.30 P. M., July 15, time $\frac{1}{60}$ of a second, plate sensitometer 26.

The sensitive plates used in instantaneous photography, particularly the special orthochromatic, must be changed and developed in the least possible amount of actinic light or the negatives will not be clear and distinct. The record I have given of the practical experience in instantaneous photography may be of service to many in their scientific investigations.

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DESCRIPTION OF A NEW AND IMPROVED DISSOLVER FOR THE MAGIC LANTERN WITH EXHIBITION OF SLIDES. By Dr. E. P. HOWLAND, Washington, D. C.

[ABSTRACT.]

As the magic lantern has got to be the most important philosophical instrument for scientific and popular illustrations, any improvement in its constructions or arrangement for its manipulation is of scientific and public interest.

A complete dissolver for the lantern is one in which the quantity of the gases for each lantern used is regulated by separate needle valves and independent of the dissolving cock.

There should be no diminution or increase of light in any lantern caused by increasing or diminishing the supply of gases to or from another lantern. It should be so constructed that all the lanterns used could be in full light at the same time or any one or more of them extinguished or relighted without affecting the light of the other lanterns. Most of the dissolvers on the market are constructed for using with two lanterns only, and take the gases from the first lantern to illuminate the second, thereby diminishing the light from the first picture before the second gets fully illuminated, making a dark point between the change of the pictures. The advantages of a good dissolver, besides not having the picture darken down in dissolving, is so that we can have as many pictures on the screen at the same time as we have lanterns and have them all equally illuminated. We then can have different illustrations on the screen side by side, or a picture with figures dissolved in, or a background of different or changing colors with many beautiful and artistic arrangements.

A great variety of beautiful and interesting lantern slides were shown with two, three and four lanterns dissolving.

SPECTRO-PHOTOMETRIC COMPARISON OF SOURCES OF ARTIFICIAL ILLUMINATION. By Dr. E. L. NICHOLS, Cornell University, Ithaca, N. Y., and W. S. FRANKLIN, University of Kansas, Lawrence, Kan.

ON THE RADIATION OF HEAT BETWEEN METALS BY INDUCTION AND BY CONDUCTION, WITH NUMERICAL RESULTS FOR STEEL AND BRASS. By Prof. WM. A. ROGERS, Colby University, Waterville, Me.

ON THE DEFINITIONS OF THE TERMS WEIGHT AND MASS. By Prof. WM. A. ROGERS, Colby University, Waterville, Me.

THE CAUSES OF SUDDEN VARIATIONS OF ATMOSPHERIC PRESSURE. By Dr. M. A. VEEDER, Lyons, New York.

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DESCRIPTION OF APPARATUS FOR MAKING A LIGHT-WAVE THE STANDARD OF LENGTH. By Prof. A. A. MICHELSON, U. S. N., and Prof. EDWARD W. MORLEY, Cleveland, Ohio.

TWO STROKES OF LIGHTNING. By Prof. J. W. MOORE, Lafayette College, Easton, Penn.

A GALVANOMETER FOR THE VERTICAL LANTERN. By Prof. J. W. MOORE, Lafayette College, Easton, Penn.

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CHEMISTRY.

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ADDRESS

BY

PROFESSOR CHARLES E. MUNROE,

VICE PRESIDENT, SECTION C.

SOME PHASES IN THE PROGRESS OF CHEMISTRY.

I am deeply impressed with the honor which you have conferred upon me in selecting me to preside over your section during the present session; but, as I look back upon the eminent men and distinguished chemists who have preceded me in this office, and around upon those who form this section, I feel unequal to the responsibility which the position entails and the obligations which it imposes, and especially so as regards your annual address. For where one is actively and constantly engaged in a variety of pursuits of a highly technical nature, it is difficult to possess one's self of but a very partial knowledge of the advances made in chemistry, since in these busy modern days the science has developed so many special phases, and has shown in many directions so marked a physical and mathematical tendency; while, at the same time, its investigators have continued to add an enormous annual increase to the bodies with which chemistry is to deal. Hence, in reviewing the progress made in chemistry, I must content myself with a glance at some few phases and leave many as important ones untouched.

Since the isolation and recognition of oxygen by Priestley, the search for new elements, like that for new heavenly bodies, has

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formed for many a most entertaining pursuit, the facilities for which have been much increased by the use of the spectroscope and the delicate spectroscopic methods as developed by Bunsen and Kirchoff, and perfected by Nobert, Rutherford and Rowland in construction, and by Crookes, Boisbaudron, Liveing and Dewar and others in methods, and the result has been to extend continually the list of bodies which are grouped under this head. The announcement of new discoveries during the last ten years has been especially large. According to a recent statement of Dr. Bolton,[1] who has kept a careful record of these announcements, over seventy bodies have been added to the list during this time, though it will be observed that many of these so-called elements are obtained by the resolution of others which are included in the above-mentioned number. The largest number added by any observer has resulted from the joint labors of Krüss and Nilson[2] on the absorption spectra of the rare earths and reaches to over twenty. Should these discoveries be verified and the elementary character of the substances, as we now use the term elementary, be established, the possible number of compounds which would result is something enormous; but, judging from experience, few of them are likely to survive a very searching criticism. Still two in this list, scandium and germanium, have already passed the tests, and the latter, which was discovered by Winkler in 1886, has been accepted as the missing element in Mendeléeff's scheme, whose existence and properties he predicted under the name of ekasilicon.

Among the fundamental constants of chemistry there are none which occupy a more important place than the weights of the atoms of the elementary substances; and it is only natural that, from the time when the present chemical elements were recognized as such, and especially since the adoption of the atomic hypothesis as enunciated by Dalton, strenuous efforts should have been made to determine this constant for each element with all the precision of which chemical art permits. Apart from the evident necessity and advantage of knowing this constant for purposes of analysis and in chemical processes in general, an added zest was given to the pursuit by the hypothesis of evolution as developed by Prout, and extended and modified by Dobereiner, Dumas, Cooke, Pettenkofer, Odling and Gladstone in their demonstrations of the numerical

[1] J. Anal. Chem., 2, *282-283;* 1888. [2] Ber. d. chem. Ges., 20, *2134;* 1887.

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relations existing between the atomic weights of elements belonging to the same natural group; while, more recently, a deeper interest has been imparted through the discussions by Newlands, Mendeléeff, Lothar Meyer, Carnelley, Mills, Reynolds and others of the data already collected which leads to the conclusion that the properties of the elements are functions of their atomic weights and that the various weights are related according to some law of nature. Thanks to the labors of Becker, Clarke, Lothar Meyer and Seubert, the literature of the subject of the determinations of the atomic weights has been carefully reviewed, the processes collated and the data discussed so that the whole matter is now readily accessible to any one who desires to engage in further research in this field.

Since the unit weight of hydrogen is taken as the standard for comparison, while the determination of the atomic weights of a large number of the elements has been made only through the intervention of oxygen, the ratio of the atomic weights of these two elements is the most important one to be determined, for any error which may occur here will be magnified when repeated through a moderate series of other ratios. Three methods were employed by the earlier investigators for fixing this constant: (1) through the synthesis of water, which was effected by passing hydrogen gas over hot copper oxide; (2) through the exact determination of the relative densities of the two gases; (3) by weighing the quantity of water formed through the direct union of a known volume of hydrogen with oxygen. The first method was employed by Dulong and Berzelius, by Dumas, and by Erdmann and Marchand; the second by Dumas and Boussingault, and by Regnault; and the third by J. Thomsen. Of these researches, that of Dumas by the first method is by far the most important, and it constitutes one of the most memorable investigations in the history of chemistry. In this he burnt an undetermined amount of hydrogen by means of copper oxide, the amount of oxygen consumed being determined by the loss of weight of the tube containing the copper oxide, and the water formed being collected and weighed directly. The greatest care was taken to insure the purity of all the materials used, every known experimental means were employed to secure accuracy, and all the corrections which could be conceived of were applied to the results, while the experiments were carried out on a very large scale, the amount of water produced being in some

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cases as high as seventy grams. As a result, the value of the atomic weight of oxygen was, as the mean of nineteen determinations, found to be 15.9607 with a probable error of ±.007.

Notwithstanding the great intelligence and skill displayed by Dumas in the devising and execution of this research, the process is open to serious criticism, inasmuch as that the weight of the hydrogen in the water obtained is estimated by difference and hence any errors in the process are accumulated in the value obtained for the hydrogen and as this is the lighter body such errors may become very appreciable. Dumas himself recognized this, for he says: "Of all analyses presented to the chemist, that of water is the one which offers the greatest uncertainty. Indeed, one part of hydrogen unites with eight parts of oxygen to form water, and nothing would be more exact than the analysis of water if we could weigh the hydrogen as well as the water which results from its combustion. But the experiment is not possible under this form. We are obliged to weigh the water formed, and the oxygen which was consumed in producing it, and to determine by difference the weight of the hydrogen which has entered into combination. Thus an error of $\frac{1}{800}$ in the weight of the water, or of $\frac{1}{800}$ in the weight of the oxygen, is equivalent to an error of $\frac{1}{8}$ or $\frac{1}{80}$ in the weight of the hydrogen. Let these two errors be in the same direction and the total error will amount to $\frac{1}{40}$."

Dr. J. P. Cooke[1] and T. W. Richards have, however, sought to solve this problem and have contrived a very ingenious apparatus by which the weight of hydrogen burnt and of water obtained is known, while the weight of the oxygen contained is estimated by difference. For this purpose, pure, dry hydrogen was first collected in a large, glass balloon, which had previously been exhausted and weighed, and then carefully weighed again, the container being counterpoised by a second balloon of similar material and of exactly the same external volume. The balloon used had a capacity of 4961.5 cubic centimetres, weighed 570.5 grams and held about .42 grams of hydrogen. The method of compensation adopted in the weighing of the large globe was found to be so accurate that under good conditions the weight of the globe, when filled, did not vary more than one-tenth of a milligram through large changes of temperature and pressure. The filled and weighed

[1] Amer. Chem. Journ., 10, *81-110*, 1888.

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balloon was then inserted between a set of combustion furnaces so arranged that pure, dry atmospheric nitrogen should be drawn into the balloon so as to sweep the hydrogen before it. The hydrogen was thus passed over ignited copper oxide and the water produced collected in suitable condensers. Finally, pure, dry air was drawn through the whole apparatus, so that at the end of the operation the apparatus and contents were in the same condition as at the start except that the hydrogen was all in the form of water. The operation was conducted with all the precision possible, and the mean of the fifteen determinations gave 15.953 ± 0.0017 as the atomic weight of oxygen.

Dr. Scott[1] has repeated the experiments of Gay-Lussac and Humboldt for ascertaining the composition of water by volume, using an improved eudiometer in the place of the Volta eudiometer used by them, and besides seeking to attain greater accuracy by preparing purer gases, using larger volumes, measuring both gases in the same vessel and by analyzing the residue after each explosion and determining the impurities present in each experiment. The apparatus used was entirely of glass with the exception of the rubber connections to the receivers employed for holding the mercury used in exhausting the apparatus. The oxygen employed was produced from potassium chlorate or mercuric oxide and the hydrogen by electrolysis. The largest amount of impurity found present in any one of the twenty-one experiments was $\frac{1}{202}$ parts while it fell in another case to $\frac{1}{2887}$ parts. As a result of these experiments Scott finds the most probable ratio of the gases by volume in water to be $H:O = 1.994:1$. Hence taking the density of oxygen referred to hydrogen as 15.9627, he arrives at an atomic weight for oxygen of 16.01. A more recent determination of this ratio by Scott under improved conditions gave $H:O = 1.9965:1$.

In 1882 Lord Rayleigh, animated by the same motive as Dr. Cooke, namely, the desire to examine whether the relative atomic weights of hydrogen and oxygen really deviated from the simple ratio of 1:16 as demanded by Prout's hypothesis, planned an investigation for determining the relative densities of these two gases, the results of which he held when combined with the determinations of the relative atomic volumes, measured by eudiometric methods such as Mr. Scott employed, ought to lead to a true

[1] Chem. News, 56, *173–175*, 1887.

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solution; for, if both investigations were conducted with gases under the normal atmospheric conditions as to temperature and pressure, any small departures from the laws of Boyle and Charles would be practically without influence upon the final number representing the atomic weights.

A preliminary notice of this investigation has now appeared[1] from which we learn that Lord Rayleigh used a large balloon for holding and weighing his gases just as Regnault and Cooke previously had, and he discovered that in both cases an error had been introduced into the experiments owing to the failure to take into account the contraction which took place in the balloon when it was exhausted. Naturally, the balloon then displaced less air than when filled, and an error results if the simple difference of the weights of empty and filled globes be taken as the weight of the contained gas. Special attention was paid to the method of producing the hydrogen and of purifying the gas, while the apparatus connecting the generator with the receiver was constructed with fused glass joints and sealed taps, there being but one rubber connection and the leakage at this being determined at the beginning of the operation by means of a Töppler pump. By this method and applying all the necessary corrections apparent, Rayleigh finds the ratio of the densities to be $H : O = 1 : 15.884$ and combining this with Scott's latest determination for the relative atomic volumes, we have for the ratio of the atomic weights $H : O = 1 : 15.912$.

In a subsequent paper[2] Cooke and Richards have confirmed by experiment the observation made by Rayleigh as to the contraction of the balloon used by them; and, on applying this correction to their previous result, they arrive at a value of 15.869 ± 0.0017 for the atomic weight of oxygen.

Dr. Keiser[3] has also attacked this problem and has started with weighed quantities of hydrogen; but, instead of using large balloons in which to hold the gas, he has taken advantage of the singular property of palladium for occluding hydrogen to secure a container in which it may be conveniently and accurately weighed. The property of palladium to occlude hydrogen was discovered by Graham in 1868 and he showed that at ordinary temperatures it occluded

[1] Chem. News, 57, *73-75;* 1888. [2] Am. Chem. J., 10, *191-196;* 1888.
[3] Am. Chem. J., 10, *249-261;* 1888.

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many hundred times its own volume of hydrogen gas. The palladium-hydrogen which is thus formed is stable at ordinary temperatures and the metal retains the hydrogen even in a vacuum. If, however, the temperature be raised above 100°, then the gas will be expelled in a slow and regular current. Under atmospheric pressure nearly all of the hydrogen can be driven out at temperatures below 200°. By enclosing a quantity of metallic palladium in a glass vessel from which the air has been removed and saturating it with pure hydrogen, a large volume of the gas may be condensed into a small space. If now the temperature be raised gradually, the gas will be driven out slowly and regularly. If the vessel be weighed before and after the heating, the loss in weight will equal the weight of hydrogen that has been expelled. It is possible, therefore, with an apparatus of small dimensions to weigh comparatively large volumes of hydrogen. Preliminary experiments showed that 100 grams of palladium foil will readily absorb from .6 to .7 grams of hydrogen, and that with an apparatus having a volume of about 150 cm^3. and weighing 130 grams, it is possible to weigh, with great accuracy, an amount of hydrogen which in the gaseous state would occupy a volume of from 7 to 8 litres. Besides the precision gained in weighing, Keiser claims, that, by the use of palladium, the hydrogen may be obtained in a greater state of purity, since palladium possesses a selective power for hydrogen when mixed with other gases or even when in combination, as in some of the hydrocarbons, and this claim seems supported by the experiments of Graham, Wöhler, Wilm and Hempel together with those of his own.

The apparatus employed for the combustion involved a considerable number of rubber connections, but these were varnished and securely wired. By this method Keiser obtained as the mean of ten determinations a value of 15.9492 for the atomic weight of hydrogen.

Morley, whose admirable researches upon the composition of the atmosphere, and upon the drying of gases by sulphuric acid and phosphorus pentoxide, are so well and favorably known, has proposed[1] several promising plans for the determination of this important ratio, which he has been developing for some years and to which the researches spoken of may be regarded as preliminary, it

[1] Am. Chem. J., 10, *91-96*; 1888.

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is sincerely to be hoped that his health may soon permit him to carry them to a successful issue.

While presenting to the British Association a preliminary notice[1] of his experiments for determining the atomic weight of gold, Prof. Mallet suggested that the most important direction in which an advance in our knowledge of the atomic weights was to be made was by endeavoring to eliminate "constant errors," as distinguished from mere personal or casual errors of experiment, from our results. We have been taught by the example of Stas to reduce the latter to very small values by minute and elaborate precautions, but the former are always to be suspected, and all conceivable means should be used to avoid them. The following were pointed out as among the most important of such means:—

(1) In every case resort to "fractional" methods for the purification of the materials to be used, assuming the materials to be pure only when earlier and later fractions give sensibly identical results.

(2) Use great care in the study of the reactions which are depended upon for the final determinations of the atomic weights, looking especially to any possibility of the occurrence of secondary or subsidiary reactions.

(3) Adopt methods by which (*a*) the atomic weight to be determined may be connected *directly* with that of hydrogen, or (*b*), if connected indirectly by the intervention in each single determination of as *few* other elements, but in determinations by different methods of as *many* other elements as possible of supposed well-known atomic weight.

Dr. Mallet has devised a method for determining the atomic weight of gold by which the final weight may be directly connected with hydrogen. The volume of hydrogen which is evolved by a given weight of zinc of a high degree of purity when dissolved in dilute sulphuric acid is first determined and a solution of auric chloride or bromide is then treated with an excess of the same zinc. When the gold in solution ceases to precipitate, the excess of zinc is dissolved in dilute sulphuric acid and the hydrogen evolved measured. The precipitated gold is collected and weighed.

The difference between the volume of hydrogen which the zinc gives when partly used to replace a known quantity of gold and when used in replacing hydrogen only, taken in connection with

[1] Chem. News, 56, *132;* 1887.

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Regnault's determination of the relation of weight to volume for hydrogen, affords the data needed.

An advantage in this method consists in the fact that neither the weight of the gold salt in solution, nor the atomic weight of the halogen combined with the gold, nor the atomic weight of the zinc need be known, nor need the zinc used be of assured purity provided only that it be uniform in character so that a given weight of it can be depended on to yield always the same quantity of hydrogen, and there be no impurities present capable of interfering with the collection of the precipitated metallic gold in a state of purity.

Of course the error in Regnault's determination, as pointed out by Lord Rayleigh, must be corrected for here and in fact must be applied in the revision of many of the existing determinations of the weights of the various elements. The same holds true for the multitude of determinations of physical constants in which Regnault's data have been employed in the estimation of the final values.

I have dwelt at length upon these important researches, not alone because of their individual intrinsic value and interest, but because they, as well as many other recent determinations of atomic weights which might be cited, show that even yet, with all the advantages of purity of material, perfection of apparatus and precision of methods, united to great skill and extensive attainments on the part of the experimenters, the attractive hypothesis of Prout remains experimentally unproved. Many hold that the failure in the proof has been due to constant errors in the experimental processes, but Meyer and Seubert,[1] from an elaborate discussion of the determinations of the atomic weight of silver and of those of the other more important elements calculated by its means, declare that they all contradict Prout's hypothesis in its characteristic original conception and that it must therefore be looked upon as having been disproved by experiment.

Crookes[2] suggests a hypothesis which may account for certain of the discrepancies in the atomic weight determinations without resorting to the supposition of constant errors. He supposes that elements, instead of being composed of parts of matter which are identical throughout, are really composed of groups of particles which are only approximately alike and whose weights only approximate to that average which we call the atomic weight. Hence it is

[1] Ber. d. chem. Ges., 18, *1098;* 1885. [2] Chem. News, 54, *122;* 1886.

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possible that in different portions of such congeries different average values within small limits may obtain. Granting this, it is remarkable that such close coincidences should result as have resulted from the observations made on material obtained from widely separated sources.

The determination of molecular weights is of nearly equal importance with that of the weights of the atoms, for the validity of our modern theories of chemistry greatly depends upon the exactness with which the molecular magnitudes are defined. It is of course comparatively easy to ascertain by analysis the proportions in which the elementary substances exist in the compound and from this data to calculate an empirical formula which satisfies, but which may be but some multiple of the true molecular formula. Thanks to Avogadro's law we are able, when the substance can be obtained in the gaseous state, to determine which among the derived expressions is the true one; for we have only to determine the vapor density by the methods of Dumas, or Hofmann, or Victor Meyer, by the diffusion method of Graham, or by others which have been suggested, and the number found is a close approximation to one-half the true molecular weight. When, however, the body could not be completely volatilized unchanged at temperatures conveniently realized we have, until recently, been dependent upon isomorphism and the laws of molecular volumes and of specific heats and upon analogical comparisons to furnish us with estimates of the molecular weights.

When the bodies are volatile, but at temperatures so high that our methods for determining the vapor densities are unavailable, we may avail ourselves of this function as a measure of the molecular weights; for numerous observations have shown that the relative volatilities of substances depend not only on the composition of the bodies but also on their molecular weights, and in general other things being equal the volatility increases inversely as the molecular weight. Unfortunately from the study of volatile liquids it has been found that among metameric bodies the rule is modified and the effect of the molecular grouping of the atoms becomes noticeable, while in some isologous series the rule is reversed, so that the method has but a limited application while the results at the best give but rough approximations to the true molecular weights.

It is held that "a closer investigation of the internal movements of liquids especially friction, diffusion and conductivity of heat

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will yield the safest means of determining the weights of the molecules which actually exist in the liquid state. But the theory of these phenomena would require a special development based on a definite idea of the properties of the molecule before it would be possible to draw conclusions as to the values for the molecules from the observations which have been and have yet to be made."

In 1788 Blagden showed that when inorganic salts are dissolved in water the freezing points of the solutions are reduced by an amount proportional to the weight of the substance dissolved in a constant weight of water. De Coppet, in 1871–72, pointed out that when this diminution is calculated for a determinate quantity of the substance dissolved in 100 grams of water the result, which he terms the coëfficient of depression, is constant for the same substance, and that the coëfficients for different substances bear a simple relation to their molecular weights. Raoult has shown what these relations are, has extended the investigation to organic substances and to other solvents than water, and has deduced a formula, by which, knowing the weights of the substance employed and of the solvent and the depression of the freezing point, the molecular weight may be calculated. He has examined a large number of substances whose molecular weights had previously been determined by their vapor densities and the results obtained illustrate in a remarkable manner the accuracy and general applicability of this new method. Paterno and Hasini,[1] Victor Meyer,[2] Auwers,[3] Brown and Morris[4] and others have applied the method and find it in general to hold, especially when acetic acid is used as the solvent.

The process is very simple for it requires only a small beaker or test tube which is closed by a cork perforated with three openings through one of which a thermometer is passed, through the second a stirrer is passed and through the third a bit of the solid mixture is dropped in order to produce congelation. A weighed quantity of the solution of known proportions is placed in the vessel, the whole immersed in the freezing mixture, the bit of solid dropped in and the temperature of freezing noted.

Ramsay[1] has applied this method to the determination of the much discussed question of the molecular weight of nitric peroxide in

[1]Ber. d. chem. Ges., 19, *2527;* 1886. [2]Ber. d. chem. Ges., 20, *556;* 1887.
[3]Ber. d. chem. Ges., 20, *1860;* 1887. [4]J. Chem. Soc., 52, *610–621;* 1888.
[5] J. Chem. Soc., 52, *621–623;* 1888.

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the liquid state and he obtains a value which leads to the formula of N_2O_4.

There has long existed a conviction in the minds of many that the molecular constitution of bodies in the solid state was much more complex than in the gaseous, owing to polymerization, and the opinion finds support in the diminishing density and increasing molecular simplicity of such bodies as acetic acid and sulphur when subjected to high temperatures, or as has been more recently shown by Mensching and Victor Meyer[1] in the case of phosphorus and arsenic, which when at a white heat give densities equivalent to the formulas P_2 and As_2 instead of those more complex formulas which have been generally accepted up to this time.

By analogy this condensation or aggregation of molecules should proceed as we pass from the gaseous, through the liquid, the to solid state. Is it not singular that the molecular weights derived by Raoult's method for bodies in a state of solution should be identical or approximately so with those deduced from their densities in the state of a gas? This method fails to afford any indication whatever of this molecular complexity in solids and liquids. Must it not then be assumed that the solvent has effected the complete dissociation of the complex molecules present in it? If so, this probably extends to all cases of true solution without chemical action, if such there be, and this is assumed in this method, for although the solvent used has been varied, all have given similar results.

Until recently we have known little precisely about the nature of solution. It has been held by some that the phenomena of solution differ essentially from those chemical combination, inasmuch as in the former we have to do with gradual increase up to a given limit, termed the point of saturation, whereas in the latter we observe the occurrence of constant definite proportions in which, and in no others, combination occurs. "Solution obeys a law of continuity, chemical combination, one of sudden change or discontinuity."

But solution is often attended with a thermal change and from many considerations it would appear that the process is attended with the development of both chemical and physical phenomena; for by the addition of water to a concentrated solution of a chemical compound, a separation of the compound into two or more con-

[1]Ber. d. chem. Ges., 20—; 1883.

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stituents is sometimes effected, the amount of chemical change being frequently dependent on the relative masses of the water and the dissolved compound and the temperature. If the masses are kept constant, the amount of chemical change, in some cases, increases as the temperature rises, and the original compound is re-formed on cooling.

This decomposition may proceed even at ordinary or below the ordinary temperatures, as for instance in a saturated solution of ammonium acetate, which loses ammonia when a current of hydrogen is passed through it even at 0°, showing that the solution probably contains free ammonia and, if so, free acetic acid also; or in an aqueous solution of ferric chloride, which undergoes partial separation into hydrochloric acid and a soluble form of ferric hydroxide, the amount of separation increasing as the dilution increases.

"Analogies have been traced between such changes as these and processes of dissociation. But even the simplest case of so-called dissociation in solution presents much more complex phenomena than a case of true dissociation. The action of water has been compared to that of pressure; dilution has been regarded as analogous to decreased pressure. In most of these so-called dissociations, water is one of the constituents of the dissociating system; hence, judging from the supposed analogy, we should expect the process to become slower and finally stop as the quantity of water increases. But the reverse of this actually occurs. The water probably exerts two actions: one which may be called physical whereby an increase in the quantity of water gives greater freedom of motion to the particles of dissolved substance, and also lessens the chances of combination between the separated constituents of the substance; and another, which may be called chemical, whereby an increase in the quantity of water determines the formation or decomposition of definite compounds which would not otherwise be produced. While an increase in the quantity of water may in one respect tend to increase the amount of chemical change, it may, in the other respect, exert an influence in the opposite direction. When the physical is more marked than the chemical action of water, we shall have phenomena resembling those presented in gaseous dissociation."[1]

Some of the advocates of the chemical view have urged that solution was attended with the formation of hydrates varying with

[1] Elements of Thermal Chemistry, Muir and Wilson.

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the dilution. This hydrate theory has been studied by Thomsen from a thermo-chemical standpoint, and considering the whole of his investigation on the heats of solution and dilution of acids, alkalies and salts, he holds that the results he has obtained are altogether opposed to the supposition that aqueous solutions of these compounds contain various hydrates differing in composition with the amount of water present. His results rather point to the hypothesis that when an acid, an alkali, or a salt, dissolves in water, either a hydrate is formed and dissolves as such, or the compound is dissolved without combination with the water, and that an increase in the quantity of water does not affect the chemical composition of the solution. At the same time dilution is always attended with a thermal change, the cause for which he finds in the changes of the states of motion of the particles of the solutions. When two liquids mix without any tendency to separation, it is suggested that such changes in the motion of the two kinds of particles occur as result in the formation of a homogeneous liquid, the particles of which are in equilibrium because the mean motions of the different particles are the same. But this mutual accommodation of the particles is accompanied by a transference of energy from one kind to another, and it is to such transferences of energy that the cause of the thermal changes is to be referred.

In a series of valuable papers, W. W. J. Nicol has also sought to show that the hydrate theory is untenable, and his conclusions have met with approval.

Mendeléeff[1] has recently put forward the following hypothesis: solutions may be regarded as strictly definite, atomic, chemical combinations at temperatures higher than their dissociation temperatures. Definite chemical substances may be either formed or decomposed at temperatures which are higher than those at which dissociation commences; the same phenomenon occurs in solutions; at ordinary temperatures they can be either formed or decomposed. In addition, the equilibrium between the quantity of the definite compound and of its products of dissociation is defined by the laws of chemical equilibrium, which laws require a relation between equal volumes and their dependence on the mass of the active component parts. Therefore, if the above hypothesis of solution be correct, comparisons must be made of equal volumes; the specific gravities are the weights of equal volumes, and moreover we

[1] J. Chem. Soc., 51, 778-782: 1887.

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must expect the specific gravities of solutions to depend on the extent to which the active substances are produced; therefore, the expression for specific gravity s, as a function of the percentage composition p, must be a parabola of the second order, while between two definite compounds which exist in solutions we must expect that the differential coëfficient $\frac{ds}{dp}$ will be a rectilinear function of p. This consequence can be verified by experiment while at the same time it affords the means for ascertaining what are the definite combinations existing in the solution. Applying this method to the solution of water and alcohol he finds three definite combinations to exist, two of which he isolated and he demonstrates graphically the rectilinear character of the differential coëfficient.

This hypothesis respecting the rectilinear character of the differential coëfficient has been proved by Mendeléeff to be correct, not only for solutions of a hundred different salts but also for solutions of H_2SO_4, NH_3, HCl and similar substances, and not a single exception has been met with.

Crompton[1] has extended this theory of solution to the discussion of the electrical conductivity of aqueous solutions; taking for this purpose sulphuric acid and a number of other typical substances. In a recent paper Mendeléeff has concluded, from a discussion of the data for sulphuric acid, that this acid forms four hydrates and, of the four deduced, two were already recognized by chemists. Now taking the curves which show the relation between electrical conductivity and percentage composition, plotted from data supplied by Kohlrausch, Crompton sought, by treating the electrical conductivity as a function of the percentage composition and differentiating in Mendeléeff's manner, to determine if this curve could not be broken up so as to give evidence of the definite hydrates above mentioned. The first differential coëfficient failed to do this; but assuming that the function might be of the third order, and taking the second differential coëfficient, a curve resulted which consisted of a series of rectilinear curves showing breaks which occurred at the points corresponding with the composition of the hydrates discovered by Mendeléeff, with the addition of one other.

This most important concurrence, with Mendeléeff's result, besides helping to confirm the latter proves that the electrical conductivity of sulphuric acid, if not wholly due to, is largely influenced by, the formation of definite hydrates in solution; and that the recti-

[1] Chem. J. Soc., 52, *116-125*; 1888.

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linear character of the second differential coëfficient curve gives us the means of ascertaining what hydrates there are which exercise this influence.

At the Montreal meeting of the B. A. A. the President, Lord Rayleigh, said in his address, "From the further study of electrolysis we may expect to gain improved views as to the nature of the chemical reactions and of the forces concerned in bringing them about . . . . . I cannot help thinking that the next great advance, of which we have already some foreshadowing, will come on this side. And if I might without presumption venture a word of recommendation, it would be in favor of a more minute study of the simple chemical phenomena."

In presenting his theory on electrolytic conduction, in which he holds that in the case of composite electrolytes, such as mixtures of sulphuric acid, or hydrogen chloride and the like with water, electrolysis is the outcome of the combined action of the E. M. F. and of some effect which the one set of molecules exerts upon the other set, while both are under the influence of the E. M. F., Dr. Armstrong[1] contends that, thanks to Mendeléeff, the great advance of which Lord Rayleigh spoke is no longer far distant, and that it is patent that electrolysis is primarily an affair of molecules; that electrolysis takes place in consequence of an influence which one set of molecules, *A*, exercises upon another set of molecules, *B*. The results which Mr. Crompton has obtained are to his mind conclusive on this point, the information afforded by the study of sulphuric acid solutions being alone sufficient; and they are of special importance as indicating the superiority of electrical values over all others in any discussion of the constitution of complex systems of dissociable compounds. This was to be expected, as, on the hypothesis under discussion, the variations in the electrical values would represent variations in the extent to which the one set of molecules affect the other set, the electrical values serving in fact to quantify an influence, for changes in constitution or structure might well occur which would involve but a slight degradation of energy and consequently a slight change in density and many other physical properties, and which yet might lead to a relatively very considerable change in the extent to which the compound could exert an influence on the course of electrolytic or chemical change. In the case of sulphuric acid the evidence is

[1] J. Chem. Soc., 52, *126–188;* 1888.

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all but complete, and it is no exaggeration to say that every peculiarity of the acid is faithfully pictured in the second differential coefficient curve.

Mendeléeff's hypothesis is supported also by the results obtained by Pickering in his study of the heat evolved by the dilution of solutions of calcium chloride. Taking temperature and percentage composition as his factors he has found a second differentiation necessary to reduce the original curves to straight lines. Owing to the multiplicity of the breaks and the smallness in percentage differences corresponding to each additional molecule of H_2O, it was extremely difficult, in some instances, to locate the exact position of breaks; but by taking the densities of the solutions, and treating the curve as Mendeléeff had done, the points at which the breaks occurred in the curve corresponded precisely with those in the heat curve, and they corresponded as accurately as could be expected with definite molecular proportions of water.

Judging from the inspection of the periodical literature, Lord Rayleigh in recommending the more minute study of the simpler chemical phenomena was but voicing an opinion which had formed itself in the minds of many investigators, and the results of these efforts show that in the case of many of the most familiar chemical processes, the reactions are quite complex and are dependent upon a variety of conditions. Even the well-known case of the decomposition of potassium chlorate by heat is shown by Teed and by Frankland and Dingwall to be extremely complex, thus confirming the assertions of Maumené. As has long since been accepted for reactions such as take place in mixtures like gunpowder, the equations usually given for the simpler chemical reactions can only represent the initial and final states for a single set of conditions.

Berthollet urged the study of these conditions more than eighty years ago when advancing his views on the nature of affinity, which he held to be a phase of the same fundamental property of matter as that to which universal gravitation owes its origin, the action appearing more complicated than gravity because of the close proximity of the reacting substances; for, under the circumstances the phenomena are influenced not only by the mass and distance of the smallest particles or molecules, but also by their form, their distances from one another and the peculiar conditions under which they exist, and he sought to explain these phenomena through the application to them of the general laws of statics and dynamics.

In his masterly work on the Modern Theories of Chemistry, Dr.

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Lothar Meyer shows from the discussion of an immense amount of experimental data, that unless all indications prove deceptive, the immediate future must bring us considerably nearer to a kinetic theory of affinity, if it succeeds, as we may hope, in obtaining a definite notion of the true nature of electricity as a peculiar form of motion.

"The chemical statics, or, as we may now call it, the chemical mechanics which Berthollet created at the beginning of the present century, will receive a totally different shape from the introduction of the hypotheses and theories which have been and which in the future will be generally accepted.

Although all the views and hypotheses from which Berthollet started have undergone transformation, the aim he had in view remains unaltered. It is still the application of the general laws of static and mechanic laws to chemical phenomena.

The best proof that Berthollet was right in his endeavors lies in the fact that the goal he had in view remains unaltered. The completion of his work, which was interrupted for many years, has recommenced, and has been energetically pushed forward in the last few years by means of the excellent methods we now possess. The work is troublesome, but comparatively easy. The old frame will be refilled with the new material which the prosperous development of the science has since yielded and daily continues to yield. The completion of the work will demand much time and energy, but rich will be the reward. It will erect a fitting monument to the glorious genius of the founder."

The progress in analytical and descriptive chemistry and in the production of new compound bodies continues at such a pace and is so fertile in results that the mere enumeration of them would occupy more time than is at my disposal. But we notice as most important the isolation of fluorine by Moissan,[1] after three years of labor; the isolation of the radical substance, hydrazine, by Curtius;[2] and the discovery by Gibbs,[3] of a remarkable series of bodies (with molecular weights reaching to over 20,000, and possessing a molecular complexity which equal if they do not exceed any known to organic chemistry) which have been produced during his researches on the complex inorganic acids. Organic chemistry is now cultivated to an extent, especially in this country, which must be very gratifying to my distinguished predecessor, who, but eight years

[1] Ann. chim. phys. 12 [6] *473–538;* 1887. [2] Ber. d. chem. Ges., 20, *1634*, 1887.
[3] Am. Chem. J., 1879–1887.

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ago, made from this chair a sound and urgent plea for its wider recognition. A marked feature of this recent advance has been a more complete effacing of the boundaries which were formerly thought to distinguish inorganic from organic chemistry.

I must pause here in my hasty sketch to note a very curious relation which has been observed by Dr. Blake[1] between the quantivalence of the inorganic elements and their biological action when injected into the circulatory systems of living animals. He has employed salts in which the electro-positive elements varied in valence from one to four, and he found that the biological action extended with the valence, the action of univalent elements being confined to the pulmonary arteries, while with the quadrivalent elements the respiratory, the vasomotor and inhibitory centres, the brain, spinal marrow, cardiac ganglia and pulmonary arteries were all affected. Dr. Blake has already demonstrated the important part played by isomorphism and atomic weight in acting upon living tissue and now regards valency as another important factor. These relations may furnish important assistance in researches in molecular chemistry. It must not be forgotten that when Newlands published the "periodic law" he made the interesting observation that all the elements which are found in organized bodies have atomic weights below forty. It may be now added that all the electro-positive elements found in organized bodies are univalent or bivalent.

Among the many hypotheses concerning matter which have been devised there is probably none, and certainly none in recent times, which has been the subject of more searching criticism than the evolutionary hypothesis. Although the doctrine is, in the main, a very old one and has been presented in various forms for more than three centuries yet it has only met with wide acceptance and almost equally wide antagonism since Darwin and Wallace first published their theories of natural selection, as based on the evolutionary hypothesis, some thirty years ago.

Although the argument of these masters was most powerful and supported by a wonderful array of experimental and observational data yet its success was no doubt in a great measure due to the fact that it was an additional proof of the operation of the law of continuity in nature; the action of which, as set forth in the neb-

[1] Compt. rend., 106, *1250;* 1888.

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ular hypothesis, so well explained the origin and development of the heavenly bodies. This noble hypothesis of Kant's which was placed on a secure foundation by La Place and presented in a clear and luminous form, with a masterly grouping of the evidence by Herschel stands to-day as one of the noblest speculations of science and the grandest example of the application of the doctrine of evolution, yet Newcomb is obliged to say of it that "at the present time we can only say that the nebular hypothesis is indicated by the general tendencies of the laws of nature, that it has not been proved to be inconsistent with any fact, and that it is almost a necessary consequence of the only theory by which we can account for the origin and conservation of the sun's heat, but that it rests upon the assumption that this conservation is to be explained by the laws of nature as we now see them in operation. Should any one be skeptical as to the sufficiency of these laws to account for the present state of things, science can furnish no evidence strong enough to overthrow his doubts until the sun shall be found growing smaller by actual measurement, or the nebulæ be actually seen to condense into stars and systems."

In fact it is probable that an enormous period of time must elapse before data can be obtained by direct observations of this kind on our solar system which will prove or disprove this hypothesis. It is true that other methods of research have been employed in the tests of this hypothesis with varying results. Thus it has been found that as more powerful telescopes have been constructed fewer nebulæ have resisted resolution and this evidence has tended to undermine the hypothesis; on the other hand, the evidence furnished by the spectroscope has in general shown an increasing complexity of constitution as we pass from the nebulæ to the suns and this has tended to support the hypothesis. But neither of these yields the final and convincing proof which is demanded.

So too as regards living things although reproduction may go on in certain of the lower orders of organized beings so rapidly, that variations so marked may be produced in successive generations by changes of environment and qualifying conditions as to point strongly to the possibility of the passage from one species to another and hence the common origin of all, yet the absolute proof is wanting, and we are dealing here with such complicated structures and obscure forces that it is a question whether the absolute proof can be obtained by the present methods of research.

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In geology and mineralogy too, though many of the changes of the contour of our earth have been observed in actual operation and many of the well-known minerals have been formed artificially, and the transition of several species has actually been traced while taking place in nature, yet here the number of factors involved is so great, and the time factor especially is so large that many breaks must and do exist in the continuous series.

It is apparently to physics and chemistry that we should first look for the experimental facts which prove or disprove the doctrine of evolution as founded upon the law of continuity, for here we deal with matter in its simpler forms and forces in their simpler manifestations, while it is possible to so reduce the factors in our experimental equations that they may be varied with comparative ease and in a comparatively short time, so that the entire operation can be conducted under our own observation. Besides, since all bodies are composed of the matter with which chemistry deals, and affected largely by the forces with which physics deal, it seems the logical method of procedure, when possible, to begin with the study of the fundamental and simpler forms and to build the superstructure of our theory upon the data so collected.

As a fact we already owe to both these sciences the existence of positive evidence of the truth of the doctrine of evolution; for the synthesis or creation of compound bodies and their analysis or disintegration are operations which are being daily conducted in our laboratories and workshops at the will of man, and these changes are not wrought upon inorganic matter only, but bodies such as urea, alcohol, alizarine, vaniline, indigo, and a multitude of others, which are the products of so-called vital processes, have been formed in this way from their elements by purely chemical processes; while by the methods of substitution and metathesis whole series of homologous hydrocarbons, identical with those existing in nature, have been evolved from elementary matter, and further we find in allotropism, isomerism (in its various degrees), and isoallomerism, in the behavior of the compound radicals, and in the changes wrought by changes in the factors of time, mass and temperature, positive evidence of the effect of environment and qualifying conditions in determining the production of species. In truth the evidence supplied is so strong as to have forced the conviction in the minds of many of the ablest chemists that all matter is one and varies only as it is acted upon by force, while on the

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other hand the transformations of energy which are continually to be seen occurring in nature and in art as continually prove the truth of that glorious conception, the doctrine of the conservation of energy, and equally force the conviction that all energy is one and varies only in its manifestations.

The belief in the unity of matter is as old as philosophy, and, as has been said, this belief has in recent time been strengthened to conviction by the development of such facts as I have alluded to above, and this conviction has been supported by the more recently discovered evidence that the properties of the elements are functions of their atomic weights and that the elements when arranged according to their atomic weights fall into natural and periodic groups; for it is a fundamental deduction from the law of periodicity that the various elementary atoms must be aggregations or condensations of one and the same primordial substance. Strong however as the conviction resting upon this evidence may be, there is yet lacking the crucial proof; for we have as yet failed to observe the passage of matter from the form of one elementary substance to that of another, or the resolution of any element into or its creation from primordial matter.

The case for the evolution of the elements from primordial matter or protyle has been very ably summed up by Crookes in his addresses to the British Association[1] and to the Chemical Society[2] and the arguments from analogy are presented in a most powerful manner, while in addition he has brought forward experimental proof of the possible existence of bodies (like praseo- and neodymium, the series of elemental bodies made known to us by Krüss and Nilson, and the numerous separate bodies into which it is probable that yttrium, erbium, samarium and other "elements" commonly so called, have been and are being split up) which, though neither compounds nor mixtures, are not elements in the strictest sense of the word. These bodies, which he styles meta-elements, consist of different groups which shade off so imperceptibly, the one into the other, that it is impossible to erect a definite boundary between any two adjacent bodies and to say that the body on this side of the line is an element, whilst the one on the other side is non-elementary, or merely something which simulates or approximates to an element. Yet by means of fractiona-

[1] Chem. News, 54, *115;* 1886. [2] Chem. News, 57, *103;* 1888.

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tion these bodies may be separated one from the other and then they exhibit slight spectral differences.

Nordenskiold[1] has also shown that gadolina, which is a crude mixture of the yttrium group that may be precipitated from the minerals containing these earths, has a constant atomic weight and hence that these elements always occur in nature in the same proportion. If this be true for one it may be true for other cases and thus the idea of an element as something definite, primary and ultimate seems to be growing less and less distinct.

Finally, Grünwald has announced that during a mathematical investigation of the changes which the properties and especially the spectra of two bodies undergo when they unite to form a new substance, he has discovered a simple and important proposition of a future chemico-mathematical theory of perturbations, and by its means has shown the compound nature of hydrogen and oxygen and has demonstrated the dissociation of hydrogen in the sun. The method employed is a spectral one and requires conditions which cannot be reproduced at the will of man, so that if it stands the tests of criticism, which is doubtful, it will not then enable us to witness the evolutionary process in actual operation. Hence, we find for the doctrine of evolution in the domain of chemistry that the tests yield absolute results only when applied to compound matter, and that the extension of the doctrine to the genesis of the elements is a pure speculation which bids fair at present to be as incapable of absolute proof as is the nebular hypothesis.

[1] Compt. rend., 103, Nov. 2, 1886.

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PAPERS READ.

COÖFFICIENTS OF VOLATILITY FOR AQUEOUS CHLORHYDRIC ACID. By Prof. ROBERT B. WARDER, Washington, D. C.

[ABSTRACT.[1]]

AQUEOUS chlorhydric acid may be represented by the formula $H_2O + nHCl$, where n is the number of molecules of the acid, divided by the number of molecules of water. If the composition of the distillate formed at any moment (under certain experimental conditions) is $H_2O + vn$ HCl, the factor v expresses the "coëfficient of volatility."

When dilute acid ($n = .07$ to $.11$) was subjected to rapid fractional distillation, the experiment agreed with the equation

$$v = 445n^3.$$

With slower boiling, the values of v were reduced from ten to thirty per cent.

When strong acid ($n = .15$ to $.20$) was boiled rapidly, the values of v were approximately represented by the equation

$$v = 3036n^4.$$

The results are illustrated with diagrams, and are discussed with reference to the thermal problems involved.

ON A NEW METHOD FOR THE DETERMINATION OF THE ATOMIC WEIGHT OF OXYGEN. By Prof. W. A. NOYES, Rose Polytechnic Institute, Terre Haute, Ind.

[ABSTRACT.]

THE apparatus which it is proposed to use consists of a U-tube filled with copper oxide, to one side of which is attached a tube with a capacity of about 20 cc. and to the other side a three-way stop-cock. The U-tube will contain 80 to 100 grams of copper oxide. It is made of hard glass and can be heated while the rest of the apparatus remains cold. In using

[1] This paper may be expected in full in the Annual Bulletin of the U. S. Geol. Survey for the chemical and physical division.

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the apparatus, it is heated, exhausted by means of a Sprengel air-pump, cooled and weighed. The portion containing the copper oxide is then heated in an appropriate air-bath and a gram or more of hydrogen is passed in. The hydrogen is converted into water by the copper oxide and the water formed condenses in the side-tube referred to above. The apparatus is then cooled and weighed. After weighing, any gases which may remain in the apparatus are pumped out and analyzed, and thus a correction which may be necessary for impurities in the hydrogen is obtained. The apparatus is heated at the same time and all of the water formed is expelled. By weighing again, the amount of oxygen taken from the apparatus is determined.

The advantages of the method are: the weight of the hydrogen is found directly as the difference of two weights subject only to a small correction for impurities; the weight of the oxygen is also found directly and independently of the weight of the hydrogen; each is weighed in a vacuum, and by using a proper counterpoise any correction for the buoyancy of the air becomes unnecessary; impurities in the hydrogen and especially any nitrogen which it may contain will be detected; finally, there can be no error from incomplete combustion of the hydrogen.

HAMPE'S METHOD OF DETERMINING Cu_2O IN METALLIC COPPER. By Prof. FRED. P. DEWEY, Smithsonian Institution, Washington, D. C.

[ABSTRACT.[1]]

THE author found that Hampe's reaction $3Cu_2O + 6\,AgNO_3 + 3H_2O = H_6Cu_4N_2O_{12} + 2CuN_2O_6 + 6Ag$, whereby two-thirds of the copper is converted into an insoluble nitrate and remains with the Ag precipitated on treating pure Cu_2O, with $AgNO_3$ in neutral solution, is modified by the presence of Cu as follows:

$$4Cu_2O + Cu + 6AgNO_3 + 6H_2O = 2H_6Cu_4N_2O_{12} + CuN_2O_4 + 6Ag.$$

That is, all the Cu_2O present in the metallic copper remains in the insoluble material.

ON THE CONSTITUENTS OF WINTERGREEN LEAVES. (GAULTHERIA PROCUMBENS, LIN.) By Prof. FREDERICK B. POWER and NORBERT C. WERBKE, Madison, Wis.

[ABSTRACT.]

IN this investigation the authors have isolated the hydrocarbon or terpene from the volatile oil of wintergreen, which was stated many years ago by Cahours (Ann. Chim. Phys. (3), 10, p. 358) to be contained therein,

[1] Published in full in Proc. U. S. National Museum for 1888.

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and have confirmed and determined some of its physical properties. They find the terpene to be present in very much smaller amounts than has been previously stated and generally accepted. The distinguishing characteristics of the oil of wintergreen and the closely related volatile oil of sweet birchbark (*Betula lenta*, Lin.) are also demonstrated.

Experiments were furthermore made to ascertain whether the crystalline poisonous principle, isolated by Professor Plugge, of Groningen in the Netherlands, from the leaves of several ericaceous plants, and termed by him *andromedotoxin*, is also contained in the leaves of the Gaultheria or wintergreen. This is proved not to be the case.

On the Oxidation of Nitro-p-xylene with Potassium Ferricyanide

By Prof. W. A. Noyes, Rose Polytechnic Institute, Terre Haute, Ind.

[Abstract.]

A series of experiments has been conducted for the purpose of discovering any general laws which may govern the oxidation of benzene derivatives by potassium ferricyanide. One of the most interesting results of the work has been the discovery, by Moses and myself,[1] that meta-nitrotoluene is oxidized with much greater difficulty than ortho-or para-nitrotoluene. This rendered it probable that if mono-nitro-para-xylene were subjected to the action of the agent in question, it would yield β-nitro para-toluic acid $\left(C_6H_2\begin{smallmatrix}CO_2H\ 1.\\NO_2\ \ 2.\\CH_3\ \ 4.\end{smallmatrix}\right)$, a substance unknown at the time this investigation was begun. On carrying out the oxidation, the acid was obtained, as expected, but only in small quantities. Larger amounts of the acid were obtained by starting with nitro-para-toluidine and converting it by means of Sandmeyer's reaction. This method has recently been used independently by St. Niementowski.[2]

Barium, calcium and copper salts of both the nitro and the amido acid were prepared and analyzed.

A second product of the oxidation was a substance having the composition of nitro-tere-phthalic acid with the addition of two molecules of water. As this substance could not be obtained by crystallizing nitro-terephthalic acid under a variety of conditions, and was only formed by the oxidation of nitro-xylene by potassium ferricyanide, the water is probably water of constitution and not water of crystallization. The substance probably has the formula, $C_6H_2\begin{smallmatrix}C(OH)_2\\NO_2\\C(OH)_2\end{smallmatrix}$, and its formation is analogous to the formation of ortho-sulphamine acids where sulphinides would be expected.[3]

[1] Am. Chem. Journal, 7, 149. [2] Ber. d. Chem. Ges., *21;* 1992.
[3] Am. Chem. Journal, *8*, 179.

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PROPYLIDENE DI-ETHYL AND DI-METHYL ETHERS. By Prof. SPENCER B. NEWBURY, Cornell University, Ithaca, N. Y.

[ABSTRACT.[1]]

BY the action of ethyl alcohol and methyl alcohol on propionic aldehyde in presence of glacial acetic acid, propylidene di-ethyl ether and propylidene di-methyl ether were obtained, the former the next higher homologue of ordinary acetal. The reactions which took place are as follows:—

$CH_3—CH_2—CHO + 2C_2H_5OH = CH_3—CH_2—CH(OC_2H_5)_2 + H_2O.$

$CH_3—CH_2—CHO + 2CH_3OH = CH_3—CH_2—CH(OCH_3)_2 + H_2O.$

Propylidene di-ethyl ether boils at 122°C.; spec. grav., 0.8473 at 0°.

Propylidene di-methyl ether boils at 86°–88°C.; spec. grav., 0.8657 at 0°.

A NEW VEGETABLE DYE. By Dr. THOMAS TAYLOR, U. S. Department Agriculture, Washington, D. C.

[ABSTRACT.]

A RICH crimson liquid extracted from a mushroom of the genus *Lactarius*, when applied to paper produces a delicate salmon tint. An alkali applied to the paper thus stained changes the tint to lilac, thus affording a test for alkalies. The lilac color changes again to salmon on the application of a weak acid.

FATAL POISONING BY CARBON MONOXIDE. By Prof. W. P. MASON, Troy, N. Y.

[ABSTRACT.]

THREE deaths, and a number of serious illnesses, were caused by the breaking of a "fuel gas" main, and the consequent escape into adjoining houses of an odorless gas containing 37.5 per cent carbon monoxide. A specimen of blood which was taken from the heart cavity of one of the victims, although twenty months had elapsed since it was collected, still presented the same brilliant red color, and gave the spectrum absorption bands as strongly as when fresh.

THE SAFETY OF COMMERCIAL KEROSENE OILS. By Prof. SPENCER B. NEWBURY, Cornell University, Ithaca, N. Y.

[ABSTRACT.[1]]

TESTS made by the author show that the oil in modern lamps with circular or double wick often becomes heated to 110° to 112° F., a tempera-

[1] The full text of this paper will appear in the American Chemical Journal.

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ture considerably above the usual legal flashing point. As, however, it is not yet proved that the vapor of oils of high flashing point is capable of giving dangerous explosions with air at any temperature, experiments were made in the hope of establishing a clear relation between the flashing point and the danger of explosion.

The following conclusions were reached:

1. All the paraffines up to decane, and probably also higher members of the series, will at suitable temperatures form explosive mixtures with air.

2. Oils which flash at a point considerably above 100° F. may under proper circumstances give violent explosions at their flashing temperature.

3. An oil consisting of pure decane, $C_{10}H_{22}$, would be accounted a safe oil by the legal flashing point test of New York state, while one consisting of nonane, C_9H_{20}, would be below the standard.

A sample of illuminating oil of good quality yielded on fractional distillation about one and one-half per cent of octane, and notable quantities of nonane and decane. To samples of the same oil, and also to samples of "mineral sperm" oil, varying proportions of pentane, hexane and heptane were added, and the reduction of the flashing points noted.

These experiments show that an oil heated above its flashing point is dangerous, whether that point be high or low. Oils which flash below 120° F. are not safe to use in the powerfully-heating lamps which are now so largely employed.

LAKE ERIE WATER AT CLEVELAND, OHIO. By ALBERT W. SMITH, Cleveland, Ohio.

[ABSTRACT.]

AN account of a chemical examination of the water with reference to locating the new tunnel of the Water Works' Department.

SOME NOTES ON PROGRESS IN CHEMICAL METHODS OF WATER ANALYSIS WITH ESPECIAL REFERENCE TO THE AMMONIA PROCESS. By Prof. FRANK H. MORGAN, Cornell University, Ithaca, N. Y.

[ABSTRACT.]

THE lines of enquiry which now demand the attention of workers in this direction may be summarized as follows:

First. A careful revision and adoption of uniform methods of procedure for those processes at present in general use.

Second. Careful investigation of modifications of the "ammonia" and

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"oxygen" processes, designed to render more definite results as to the nature and amount of organic matter in a water.

Third. Continued studies of the conditions of nitrification in the soil and its relations to purification of both well and river waters.

Fourth. Trials of new reagents in a search for means of distinguishing different kinds or conditions of organic matter.[1]

Fifth. A careful study of the relations of time, temperature, concentration and pressure to the action of reagents on the organic matter.

Sixth. A complete index to the literature of potable water analysis and carefully drawn monographs of each method in general use.[2]

The following lines of investigation are being carried on by the writer:

1. Trial of the action of a constant volume of concentrated alkaline permanganate.

Results so far obtained show no decided increase in the amount of nitrogenous matter thus converted into ammonia.

2. Trial of the amount of ammonia that may be obtained by a preliminary treatment with H_2SO_4. Application of the principles of Kjeldahl's process was suggested by Prof. E. Waller, Jour. Am. Ch. Soc., 8, 150, but no results have as yet been published.

Present progress of the writer shows the possibility of a considerable increase in the amount of ammonia as compared with the total ammonia obtained by the ordinary process, but satisfactory regularity has not yet been secured.

3. Determination of the amount of ammonia developed by the action of Na_2CO_3 on the organic matter during the ordinary distillation of free ammonia.

The method used is to determine the real saline or free ammonia by direct test and subtract this from that obtained by the ordinary distillation with Na_2CO_3.

The following results have been obtained:

	Ammonia in p. p. m.		
	Direct.	Dist.	Diff.
Diluted fresh sewage	9.62	12.45	2.83
Same sewage forty-eight hours older	16.80	18.20	1.40
A well water from a suspected district (alb. am. 0.10 and nitrates n = 5. p. p. m)	.016	.023	.007

Many experiments have been made upon the details of the ammonia process. A small amount of CO_2 in a distillate may diminish the color developed by Nessler reagent. The amount of Nessler to be added to the

[1] Practically only one reagent has been in general use.

[2] The writer is making an index to the "Ammonia Process" and hopes to present a monograph at the next meeting.

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first distillate from a bi-carbonated water should not be less than 2.5 cc. for 50 cc. of distillate.

In conclusion, the adoption of a regular method of procedure in the use of the ammonia process is urged upon the association to secure uniform and comparable results from different workers. The adoption of the methods of stating results of water analysis reported last year will be of little advantage unless followed by such a revision and adoption of methods of procedure as shall render the results definite; the work of different chemists being comparable only when based upon constant and uniform conditions.

PRELIMINARY NOTE UPON IODINE AS A REAGENT IN THE ANALYSIS OF DRINKING WATER. By Prof. FRANK H. MORGAN, Cornell University, Ithaca, N. Y.

[ABSTRACT.]

A DILUTE solution $\left(\frac{n}{500}\right)$ of iodine, in presence of sulphuric acid, acts in a significant manner, bearing a definite relation to the character of the water treated.

While permanganate of potash in acid solution acts on nearly all classes of organic bodies, iodine in acid solution has a more limited and specific action.

The procedure, which has given satisfactory results, consists mainly in adding a measured amount of iodine solution to 100 cc. of the water or solution to be treated, acidifying with sulphuric acid, and subjecting to any desired temperature (generally 100° C.) in hermetically sealed flasks. After a definite time the flask is cooled, opened, and the iodine absorbed determined by titrating the free iodine by thiosulphate.

A sewage, which by the permanganate process
consumed $KMnO_4$ equivalent to 23.7 p.p. m. of oxygen.
absorbed iodine " " 7.4 " " " " " "
A river water consumed $KMnO_4$ " " 8.8 " " " " " "
absorbed iodine " " 0.87 " " " " " "

SOME MODIFICATIONS OF THE METHODS OF ORGANIC ANALYSIS BY COMBUSTION. By Prof. WM. L. DUDLEY, Vanderbilt University, Nashville, Tenn.

[ABSTRACT.[1]]

SOLID substances are burned in a porcelain or platinum boat contained in a platinum or glass tube which is open at both ends. One end is connected with the calcium chloride tube and potash bulbs in the usual manner, and the other with apparatus to purify and dry the air and oxygen which are passed through the tube during the combustion. The tube is

[1] The full paper will be printed in the American Chemical Journal.

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filled one-third full of granulated oxide of manganese prepared by strongly heating the nitrate over a blast lamp. The boat containing the substance is introduced, the collecting bulbs and tube are attached, and a current of air is passed through the apparatus. The burners are lighted under both ends of the tube and the substance is approached in the usual way. The combustion is finished in a current of oxygen.

Non-volatile liquids are placed in a boat and treated in substantially the same manner as solids.

Volatile liquids are weighed in a bulb having two tubes (each opposite the other) which are attached by rubber tubing to and between the gas purifying apparatus and the combustion tube which is filled about two-thirds full of oxide of manganese. The combustion tube is heated to redness, and a current of dry nitrogen is passed through the apparatus to act as a carrier for the volatile liquid which is slightly warmed. When all of the liquid has passed into the tube a current of oxygen is turned on to complete the combustion.

PRELIMINARY NOTE ON THE FINAL PRODUCT OF THE ACTION OF CONCENTRATED SULPHURIC ACID ON SUGAR. By Prof. FRANK H. MORGAN, Cornell University, Ithaca, N. Y.

[ABSTRACT.]

IN some experiments on the solution of carbon by the action of concentrated sulphuric acid and potassium chlorate, the writer had occasion to analyze various products of the action of sugar and sulphuric acid; the composition of these products led him to treat sugar with boiling concentrated sulphuric acid to see how nearly pure carbon could be obtained in this way. The final product obtained, upon which the acid had no more action, has an ultimate composition almost identical with Brodie's graphic acid upon which he based his determination of the atomic weight of "graphon".

Ultimate product of H_2SO_4 on sugar		Brodie's Graphic Acid $[C_{11}H_4O_5]$
Carbon	61.41	61.04
Hydrogen	1.77	1.85
Oxygen	36.82	37.11
	100.00	100.00

Further work is necessary to prove the constancy of this result.

THE CHEMISTRY OF FISH. By Prof. W. O. ATWATER, Middletown, Conn.

[ABSTRACT.]

THIS paper gives results of comparisons of analyses of American and European fishes and classifications by chemical composition.

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THE QUANTITIES OF NITROGEN IN PROTEIN COMPOUNDS. By Prof. W. O. ATWATER, Middletown, Conn.

[ABSTRACT.]

THIS paper summarizes results of determinations of nitrogen in animal tissues and discusses the nitrogen-factor of protein.

ON THE PRESENCE AND SIGNIFICANCE OF AMMONIA IN POTABLE WATERS. By Prof. E. H. S. BAILEY, Lawrence, Kan.

COMPOSITION OF SALT BRINES IN NORTHERN OHIO WITH SPECIAL REFERENCE TO ITS BROMINE AND LITHIUM CONTENTS. By Prof. C. F. MABERY and HERBERT H. DOW, Cleveland, Ohio.

THE CRYSTALS OF BUTTER AND FATS, ILLUSTRATED BY LANTERN PICTURES. By Dr. THOMAS TAYLOR, U. S. Dept. of Agriculture, Washington.

EXHIBITION OF SPECIMENS OF ALLOYS OF CAST IRON AND ALUMINUM. By W. J. KEEP, Detroit, Mich. (By request of the Section.)

THE PIERCE PROCESS OF MAKING CHARCOAL, AND EXHIBITION OF SPECIMENS OF PRODUCTS. By Prof. O. H. LANDRETH, Nashville, Tenn. (By request of the Section.)

PRESENTATION AND DISCUSSION OF LABORATORY METHODS AND DEVICES By MEMBERS OF THE SECTION.

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PAPERS READ.

THE INFLUENCE OF ALUMINUM UPON CAST IRON. By W. J. KEEP, C. E., Prof. C. F. MABERY and L. D. VORCE of Cleveland. Read by W. J. KEEP, Detroit, Mich.

ALUMINUM is a metal obtained from its oxide, alumina. It is white in color and very tenacious, and it alloys readily with iron.

Cast iron, ordinarily used, is iron which contains all the carbon that it could absorb during its reduction in the blast furnace.

This carbon, when found in chemical union with the iron, is called combined carbon. In this state it cannot be seen. It is also found mechanically mixed with the iron in the form of graphitic carbon, when it becomes visible.

Other elements commonly found in cast iron are phosphorus, sulphur, manganese and silicon.

The natural condition of carbon in iron is the combined state. The presence of silicon drives a portion of the carbon into the graphitic state.

Sulphur, manganese and phosphorus do not cause the carbon to leave its natural combined state, and if silicon be present, these elements either drive it out or overpower it.

Carbon is therefore a passive element and is made to change its form by the presence of other elements. It is this change of carbon which indicates, to the eye, the influence of any element upon the cast iron.

Iron and combined carbon, or carburetted iron, is called white iron, and the grain is generally very fine, and often even, and the metal is very hard.

Graphite darkens the fracture until it becomes a very dark gray, and the grain is coarse and irregular. With increase of graphite the metal becomes soft.

We shall confine ourselves in this paper to the influence of aluminum upon cast iron.

Let us for a moment review the present knowledge on this subject. It is known that fused wrought iron, a mixture of cast iron and steel, or steel alone, either of which would make castings which would be full of blow holes, will make solid and homogeneous castings if as small a quantity of aluminum as one-tenth of one per cent is added just before pouring. Also, that such addition causes the iron to remain fluid long enough to allow its being cast into moulds.

It seems to be the general opinion that the aluminum does not remain in the metal, but that it exerts its influence between the time of its introduction and the time of its departure.

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This seems to be the sum total of the present information regarding the influence of aluminum upon iron.

We propose in this paper to give the results of a series of very carefully conducted tests to substantiate further the statements just made, and to settle the question as to whether aluminum remains in the casting; also to determine the influence of this metal upon the physical structure and upon the composition of iron.

The physical tests that we have employed are what are known as "Keep's tests;" and by them we are enabled to make apparent to the eye the influence of any element upon cast iron.

When it was understood that we were to undertake this examination, the Cowles Electric Smelting and Aluminum Company of this city (Cleveland) kindly furnished us with what ferro-aluminum we needed, and Prof. C. F. Mabery and L. D. Vorce, of the Case School of Applied Sciences, of this city, volunteered to undertake the chemical examination of the test bars. The results of these investigations will be appreciated, when it is understood that we began without the least expectation of the very important results we have obtained, and that the methods for the determination of minute quantities of aluminum were so imperfect, that the small quantities used in the "Mitis" process could not be determined, if they still remained in the castings.

Regarding the physical tests, we should state that we use two bases: one, a white iron, with composition Si .186, P .263, S .0307, Mn .092; the other, a gray Swedish iron marked FLM, with composition, Si 1.249, P .084, S .04, Mn .187. The ferro-aluminum contained Si 3.86, Al 11.42.

The melting was done in a covered plumbago crucible, in a coke furnace driven by a blast of two and one-fourth ounces. The test bars were one foot long and cast in pairs; one, one-half an inch square and its mate one-tenth of an inch thick and one inch wide.

We started with thirty pounds of the base in the crucible; at the first heat there were cast four pairs of bars from the base alone, which took five pounds of metal. After allowing the remaining metal to become solid, we returned the runners of the first cast, and added four pounds of the base, and returned the crucible to the furnace. When nearly melted, we added enough ferro-aluminum to bring the percentage of aluminum in the whole to where we wished it for the second set of bars. We proceeded in like manner through the entire series of heats. To arrive at the influence of the aluminum, we made another series of heats, with the same base with exactly the same conditions, only we did not add the aluminum.

The difference between the two series of tests gives the effect of the aluminum.

We shall consider this subject under the following heads:

1. The solidity of castings and the prevention of blow holes.
2. Does the aluminum remain in the iron to exert an influence when the iron is remelted?
3. The effect of aluminum upon the grain, or the changing of the carbon from the combined to the graphitic state.

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4. Taking away the tendency to chill.
5. The prevention of sand scale.
6. The effect upon hardness.
7. The resistance to a load gradually applied, or a dead weight.
8. The resistance to a load suddenly applied, or impact.
9. The elasticity.
10. Permanent set.
11. The effect on the shrinkage of the iron.
12. The fluidity of the melted metal.

(1) *The solidity of castings and the prevention of blow holes.*

All of our tests bear upon this subject, but we have made one test, using the white base iron and one-tenth of one per cent of aluminum. It is almost impossible to get a solid casting of the white base alone, and its resistance to weight is generally about 175 pounds for the one-half inch square bars, and its resistance to impact is about 100 pounds. We have obtained, however, exceptionally sound castings of this base, and we shall use the strength of such castings for comparison.

These sound castings of the white base alone resisted a weight of 379 pounds. With one-tenth of one per cent of aluminum added it resisted 545 pounds, a gain of 166 pounds, or about forty-four per cent from this small addition.

Measuring the resistance to impact, the white alone was 239 pounds; with aluminum 254 pounds, or about six per cent gain.

The castings appear of slightly finer grain, and the character of the crystallization is somewhat different, but the secret of the strength lies in the closing of spaces between the grains, or in other words, in the increased solidity of the casting. No other change is noticeable in the metal.

A graphic representation of this test is not needed.

(2) *Does the aluminum remain in the iron to exert an influence when the iron is remelted?*

CHART 1.

To determine this, we made a series of six heats from the white base, and added to the first heat one-fourth of one per cent of aluminum. This amount alters the grain very perceptibly, making it whiter and finer, and removing the tendency of the base to a slight specular appearance, and giving a homogeneous fracture. It increases the strength above the base about twenty per cent to resist weight, and for impact, an increase of over seventy per cent.

The next heat was a remelt of the first, with the runners of the first cast put back, and enough white base added to reduce the aluminum to two-tenths of one per cent when the second cast was made.

Our comparisons will now be made between this series and the comparison series of the base alone. Looking at the chart we see that the effect of the aluminum in this second heat is greater than it was in the first heat to which heat the aluminum was added. This is due to the increasing porosity at each heat of the base when melted alone, and to the solidity of

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the series with aluminum. At the third and subsequent heats the same result is apparent, the remaining aluminum causing more solid castings, though the continued additions of white iron at each heat and the consequent lessening of aluminum render the castings less strong at each remelting. Yet the effect of the aluminum is so constantly apparent at each melt, as to leave no doubt as to its presence even in the sixth remelting.

The chart, which we have prepared, shows these effects both as to weight and impact.

As we proceed with the description of other tests it will be noticed that we add but a small quantity of aluminum at each heat, and depend upon the additions made at previous heats to bring up the required percentage.

The results of the tests show conclusively that the aluminum remains and exerts its influence in subsequent casts as fully as would be expected.

(3) *The effect of the aluminum upon the grain, or the changing of carbon from the combined to the graphitic state.*

Let us say a few words in regard to the way in which, and the reason why, carbon takes on the graphitic form.

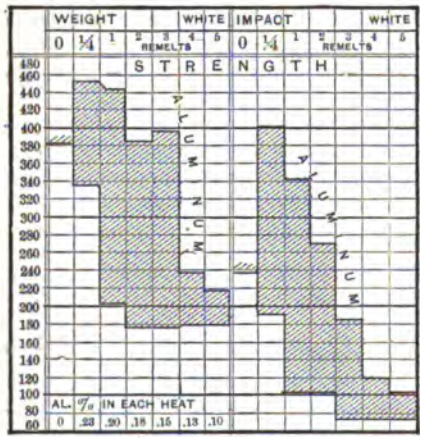

CHART 1.

All of the carbon, both combined and graphitic, which the iron is capable of holding when solid, must be dissolved and exist as combined carbon in the melted iron. Cast iron made in the usual way contains all of the carbon that it can hold.

Very often cast iron, when melted, contains more carbon than it can hold in combination when at a lower temperature; if so, as the iron cools down, such excess of carbon will separate as graphite and rise to the surface.

In any case, when a melted iron contains more carbon than the iron can hold in combination when cold, all of the excess will not be able to reach the surface, though it may not be visible to the eye, in the casting.

The introduction of other elements into the melted metal may alter its ability to hold the carbon. Sulphur causes it to let some go, while manganese enables it to hold more carbon in solution. Silicon also somewhat diminishes the capacity of the molten metal to retain carbon while it is liquid.

Aluminum allows most of the carbon to retain its natural combined form until the metal is too thick for the separated carbon to escape, but at the

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instant of solidifying aluminum causes the iron to drop a portion of its carbon from the combined state. This liberated carbon takes the graphitic form and is imprisoned in the otherwise solid iron.

The advantages arising from a change of carbon from the combined to the graphitic state, at the instant of crystallization, are that all of the carbon thus liberated is imprisoned uniformly throughout the casting, and is not accumulated in pockets forming soft and hollow spots, as would be the case if liberated while the casting was yet fluid. Aluminum more than any known element accomplishes this. It not only changes white iron to gray, but seems at once to change the whole character of the metal. The drop of carbon seems to be instantaneous, at the instant of crystallization, and for this reason the time taken in cooling has little effect.

In fact, when the aluminum obtains full control of the carbon, it would seem that the more sudden the cooling the more the formation of the graphite, and the thin portions of the casting are therefore as gray as the thicker portions.

The powerful and positive influence of aluminum upon the carbon, and therefore upon the grain and color of the iron, is shown by an examination of the series of samples that we present here to-day.

Take those made from the white iron base with almost no silicon present; the base alone gives a white bar full of blow holes. An addition of one-fourth of one per cent aluminum gives us not only a perfectly homogeneous and solid casting, but the color is darker and the grain shows that some of the carbon has taken the graphitic form.

The thin casting shows this even more than the heavier bar, showing that the change occurred suddenly and that time had but little effect.

Examining each bar in turn we see that each similar addition of aluminum produces a corresponding effect, until at the third addition, or with three-fourths of one per cent, the casting is gray with no sign of white either in the square or in the thin bar.

The set of tests with the gray iron base, containing one and one-fourth per cent of silicon, shows that silicon and aluminum work together in the same direction, and that a slight addition of aluminum takes the white out of the casting at once, giving the same grain in a thin as in a thick casting.

This effect increases as the aluminum increases, and the indications are that at least up to four per cent, the limit of our experiments, the more aluminum, the softer and grayer the castings.

(4) *The taking away the tendency to chill.*

Chart 2.

If cast iron be cooled very suddenly, the carbon, which the melted metal holds in combination, will not have time to separate and will be retained in the combined state. Such castings are called chilled castings.

Chill is caused by molten iron running against a body which rapidly withdraws its heat, causing it to retain its carbon in the combined form.

Back from the chill, where this instantaneous cooling could not exert its full effect, a portion of the carbon takes the graphitic form.

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This property is made use of when it is desirable to obtain hard wearing surfaces, and in the same casting tough and soft central portions, as in car wheels.

While this chilling effect is exceedingly valuable for many purposes, yet generally speaking, the founder desires exactly the reverse.

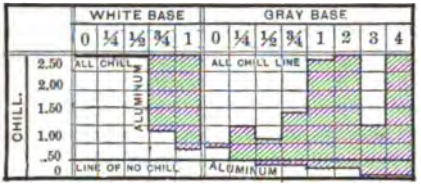

CHART 2.

Correction of Chart 2.—*Consider the 0 as belonging to the lower line of the cut, the .50 to the next line, and bring 1.00 down to the third line, 1.50 to the fourth, and so on. All these readings are inches.*

We have said that aluminum causes the carbon to assume the graphitic form on the instant of solidifying, and therefore the sudden abstraction of heat does not imprison the combined carbon and cause chill.

This effect of aluminum is to give a uniform grain for thick and thin castings, and not allow the coldness of the mould to affect the grain.

(5) *The thickness of the sand scale.*

This is an important consideration; for the sand must be cleaned from the casting, and the surface must first be cut before the interior can be reached.

To prevent the iron from burning the sand into itself and thus forming a scale, a plumbago facing is sifted on the surface of the mould, but it is difficult for the facing to lie on the surfaces or to resist the intense heat of the metal.

When aluminum in an iron causes the dropping of the graphite from the mass of the metal, that graphite which is on the surface of the casting separates and forms a perfect plumbago facing, which opposes the sand and the heat. It will therefore be seen that in castings having sufficient aluminum to cause this separation of graphite, there will be no sand clinging to the face, and that the surface will be as soft as the interior of the casting. Every iron worker will appreciate this good effect of aluminum.

(6) *The effect upon hardness.*

Hardness in cast iron is caused by the carburetted or white iron, in masses large enough to oppose the tool. If the carburetted iron exists in minute threads stretched around atoms of graphite, a tool will easily cut it and it will not be considered hard.

This graphitic carbon, minutely dividing the mass, gives the tools of the workman a chance to cut or break the films of metal, giving what we call softness to the iron. The later the carbon is dropped, the smaller will be the atoms of graphite and the closer the grain. Yet this greater subdivision will, for the reason just given, make the iron work more easily.

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The fineness of the grain of iron affected by aluminum causes such iron to be much more easily cut than iron of coarser grain.

The next question to consider is that of strength.

The power of wrought iron and steel to resist extension is so great that where such stresses are to be resisted, decarbonized metal should be used. The resistance of any cast iron to crushing is so great that we need not consider this.

The forces which cast iron structures should be made to resist, aside from crushing, are a dead weight or a blow applied transversely. We should therefore test cast iron with these forces.

(7) *The resistance to a load gradually applied, or a dead weight.*

CHART 3.

If we compare the transverse breaking weights of the two series which we have been considering, number by number, we perceive that the aluminum has increased the strength to sustain a constant load.

This is a very important effect and perhaps comes partially from the tenacity and strength of aluminum itself, but probably more from the uniform grain of the iron.

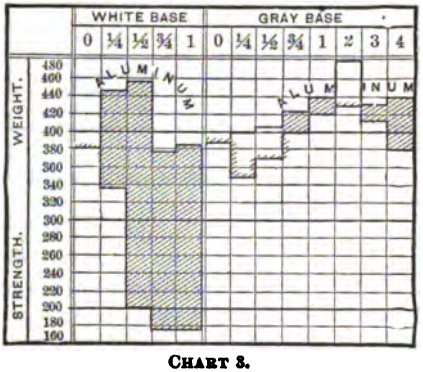

CHART 3.

(8) *The resistance to a load suddenly applied, or impact.*

It may be thought that the effect is substantially the same, whether the force be a constant weight or a suddenly applied blow. We shall at a future time prove that the effects are not the same and that an iron should be tested by a blow if it is expected to resist impact.

CHART 4.

By a comparison of the graphic representation, we see that the capacity to resist impact is increased by the addition of aluminum much more than the capacity to resist a dead weight. It will be seen at a glance that the test bars made with the white base are benefited far more than those made with the gray base. The reason for this is, that the white base alone made porous castings; at each remelt this porosity increased, due to the continuation of the heat, running the strength down to 68 pounds at the fifth heat.

The first, and each subsequent addition of aluminum, caused the castings to be perfectly sound, and the infinitesimal atoms of graphite deposited throughout the metal removed the rigidity and brittleness of the initial metal.

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The gray iron base contained enough silicon to accomplish all this, and the only effect on strength that the action of the aluminum on carbon could have, would be to increase the fineness of the grain unless the toughness of the aluminum itself could give strength to the casting, though the aluminum no doubt removed any slight blow holes that existed in the initial gray metal.

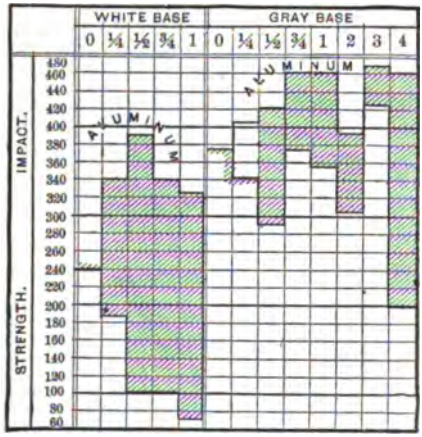

CHART 4.

This leads us to notice that each addition of aluminum increases the strength over that of the initial metal. We must expect, however, that after we have added enough aluminum to cause a solid casting, and to remove the brittleness, that the dividing up of the mass by the atoms of graphite accomplishes, any further additions of aluminum and consequent increase of graphite (which has no strength of itself) must weaken the casting.

(9) *The elasticity.*

CHART 5.

The compactness and closeness of the grain of cast iron when aluminum was the agent by which the graphite was precipitated, and the fine attenuation of the veins of the carburetted iron, cause the metal to be very elastic and, as we have seen, not so brittle as without aluminum.

(10) *Permanent set.*

This is caused by the compression of the graphite within the framework of carburetted iron. When this compression of graphite carbon is produced by transverse bending, the framework of the metal also takes on a permanent form which cannot be altered except by a greater force than was before applied.

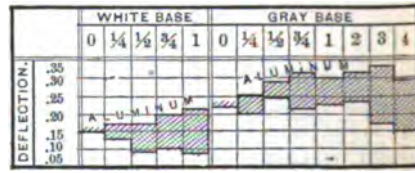

CHART 5.

The fineness and compactness of iron alloyed with aluminum gives less permanent set than iron equally as soft, when such softness is produced by silicon.

(11) *The effect on the shrinkage of the iron.*

The more suddenly and completely the carbon is changed from combined to graphitic, at the instant of crystallization, the more space will the casting occupy. When the casting is cold, it will therefore have contracted

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less than if more carbon had remained combined. White iron, having most of its carbon in the combined state, shrinks from one-fourth to one-third of an inch in each foot.

Gray iron sometimes shrinks as little as one-tenth of an inch to each linear foot. As the combined is the natural state for the carbon, we may say that this maximum shrinkage is the natural shrinkage for cast iron having its carbon combined. We can therefore say that aluminum takes out or reduces shrinkage when a sufficient quantity is added. This is a very great advantage, as shrinkage requires great skill in the preparation of patterns to prevent warping and cracking, and violent internal strains within the castings.

The lessening of shrinkage avoids these evils, and is therefore a great gain.

CHART 6.

If you will look at the chart for shrinkage, you will see the most conclusive proof of our explanation of the way in which shrinkage is lessened. With both the white and the gray bases, during the first two additions, the shrinkage of the square bar is slightly increased.

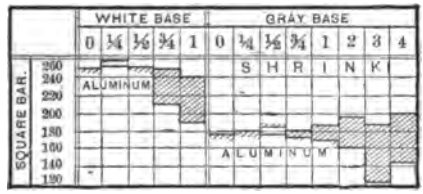

CHART 6.

The influence of the aluminum thus far has been in the direction of elimination of blow holes, and causing an even distribution of the dark and light grains.

At the third addition, however, when the amount reached three-fourths of one per cent, the effect was appreciably felt upon the carbon, as seen by the color, and as we should expect from the deposition of this large bulk of graphite, the casting does not shrink as much, and each addition of aluminum increasing this bulk of graphite decreases the shrinkage.

CHART 7.

The effect upon the grain and color of the thin bars of the series is very remarkable, showing that the aluminum has changed enough carbon to graphite to produce a dark, even grained casting.

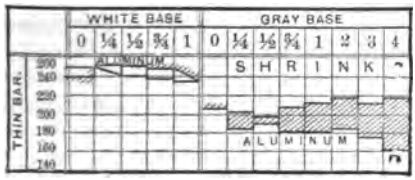

CHART 7.

The effect upon the shrinkage of these thin bars is as we should expect, and is more marked even than in the square bars.

The shrinkage in the thin bars of the white series shows a constant decrease as the aluminum increases, but in the series for comparison the shrinkage dropped still more rapidly.

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If a new crucible was used in commencing this comparison series, enough silicon might have been absorbed to produce this effect. This leads us to remark that on account of the variations of conditions in any series of tests, that cannot be foreseen, we must avoid drawing any but general conclusions, and these should be based upon a large number of experiments.

(12) *The fluidity of the melted metal.*

CHART 8.

Our tests of fluidity are correct as far as each individual heat is concerned, but variation may be due to the heat of the metal of that particular cast when poured. Viewed in a general way, the indications are that with the white base, with almost no silicon, the aluminum has increased the fluidity; but judging from the series with the gray base we would say that combined with silicon aluminum reduced the fluidity.

Our remarks in connection with shrinkage show that a sharp casting is produced by the instantaneous dropping of graphite when crystallization takes place; and that if the iron is fluid enough to fill the mould, any extra fluidity causes the iron in shrinking to draw away from the mould.

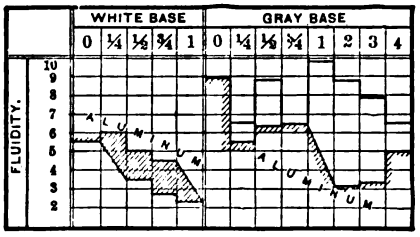

CHART 8.

Again, the percentage of aluminum necessary to bring about these desirable results will be too small to have much effect upon the fluidity of the metal.

The fact of the iron giving sharper and more perfect castings, on account of the swell of the casting, caused by the deposition of graphite at the instant of solidification, might cause the iron to be pronounced more fluid, if judged by the appearance of the castings.

No doubt the presence of varying quantities of manganese, sulphur, phosphorus and silicon, in the cast iron used, would modify the influence of aluminum, and until this is understood it may require considerable experiment to determine the amount of aluminum required, or how it shall be introduced.

This hurried presentation of the remarkable effects of aluminum upon cast iron will give an idea of the great benefit which is now promised to the iron founder by the rapidly falling price of aluminum as cheapened by the electric furnace.

We have already occupied all the time that was set apart for us.

Following the publication of this part of the subject, we shall soon present the results of the laboratory work of Professor Mabery and Mr. Vorce, which will throw still more light upon this interesting subject.

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THE SECOND LAW OF THERMODYNAMICS. By Prof. R. H. THURSTON, Ithaca, N. Y.

[ABSTRACT.]

THIS paper represents the views of its author respecting the various statements of the second law of thermodynamics given by various authors of authority. It considers the nature of a law as defined by science; compares the statements of the law to be examined, as made by many writers, and shows that they are commonly statements of simple phenomena and not of laws; and, finally, gives what is thought to be a true expression of the law which should be given place as the second law of thermodynamics, and shows in what manner it has value and where it finds application in the theories of heat-transformation and in the application of those theories and the science of thermodynamics to the operation of the heat engines.

THE ECONOMICAL PRODUCTION OF CHARCOAL FOR BLAST FURNACE PURPOSES. By OLIN H. LANDRETH, Vanderbilt University, Nashville, Tenn.

[ABSTRACT.]

THE economical production of charcoal on a scale commensurate with blast furnace needs has not received that attention and study its importance demands. Of all the charcoal produced, ninety-four per cent is used for the production of pig iron, the remaining six per cent furnishing the supply for all domestic purpose, manufacturing and the production of all metals other than iron, so that improvements or processes in charcoal manufacture to be of broad application must be applicable to blast furnace plants which are necessarily extensive. Though the ratio of production of charcoal iron to the total iron produced is decreasing, owing to the enormous increase in the output of coke and anthracite iron, the absolute amount produced is annually on the increase, since there are many purposes for which charcoal iron is essential and cannot advantageously be displaced by coke iron. Among these are the manufacture of the finer varieties of steel, the higher grades of chilling iron, malleable castings, tin plate, wire rods and for mixing with coke iron, in which it is found that the addition of a small amount of charcoal iron raises the character of the mixture for many purposes out of proportion to the amount added, so that notwithstanding the fact that it costs from $2 to $5 per ton more to produce a ton of charcoal iron than coke iron its peculiar properties maintain the demand for it, and such demand would increase and the character of manufactures would thereby be raised could its production be cheapened to admit it for those purposes for which it is desirable, but from which its price now excludes it. Fuel represents nearly one-half the cost of char-

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coal iron, and herein lies the greatest promise of reduction of cost, particularly as the methods of charcoal making at present in general use for iron making are extremely crude and uneconomical. The only exception to this which has been widely adopted is the Pierce process invented by Dr. H. M. Pierce of Detroit, Mich., now a resident of Nashville, Tenn., whose process was devised in 1876 and has since been undergoing continued improvements and developments until now (1888) nine plants under this process are in operation in the southern and western states which aggregate in capacity over 325,000 cords of wood annually carbonized, with plants under negotiation of over 250,000 cords annual capacity. By this system the by-products preserved from the destructive distillation of the wood more than meet the expenses of manufacture, leaving the charcoal produced a clear profit. In outline the process is as follows: the charring is effected in circular, flat top, brick kilns holding fifty cords of wood each. The wood is charred by the heat produced by gas burned in a brick furnace under the kiln into and through which the products of combustion pass. The gaseous products of dry distillation of the wood pass from the kiln to condensers, where the tarry and liquid products are condensed and the gas sent back to the kiln. Thus none of the charcoal produced is burned to carbonize other wood as in the common pits or ovens. The gas which elsewhere is wasted is here not only sufficient to effect the carbonizing of the wood but furnishes fuel for the boilers required about the works.

The wood used is as thoroughly seasoned as the conditions of maintaining a year's supply in advance, cost of storage room and interest on capital invested in stock render economical.

All the common varieties in the localities of the various plants are used. The proportions of the varieties used at Nashville are approximately:

Oak,	50 %
Cotton wood,	15
Hickory,	10
Gum, maple, birch and other varieties,	25
	100 %

If not thoroughly dry when placed in the kilns, the carbonization of the wood is automatically deferred, by the absorption of the heat in the evaporation of the sap and other moisture, until the seasoning process is complete. This seasoning commences at the top of the kilns and proceeds regularly downward, by a definite plane of seasoning. When this plane reaches the bottom and the seasoning is complete, which is indicated by a sudden change in the color of the escaping vapors, the process of charring begins at the top and proceeds downwards precisely like the seasoning process.

The watery vapors driven off during seasoning are not preserved but are allowed to escape through vents temporarily left open around the base of the kilns and through the top of the kiln-chimneys, which, during this stage, are disconnected from the suction main and left open at the top.

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The time required for the several stages in the cycle of operations in producing a kiln of charcoal is as follows:

For charging one kiln with wood, . .	2 days.
" completing the seasoning of the wood,	1 "
" carbonizing the wood, ...	7 "
" cooling the charcoal, ...	6 "
" drawing the charcoal, ...	2 "
Total length of cycle, . .	18 days.

As one 60-ton blast furnace requires five thousand bushels of charcoal daily, or the output of two kilns, the total number of kilns in a plant to furnish a continual supply of fuel must be equal to twice the number of days in a cycle plus a margin for relays, for repairs, and unusual delays; the margin is usually chosen at one-sixth the effective number of kilns, so that the total number of kilns comprising a plant $= 2\ (18) + \frac{1}{6}\ (36) = 42$, of which at any one time,

4	kilns are being charged and closed.
2	" " " seasoned.
14	" " " carbonized.
12	" " " cooled.
4	" " " drawn.
6	" " idle or acting as relays.
42	

These forty-two kilns are arranged in two distinct batteries of twenty-one kilns each. Each battery has its own condensers and suction main carrying the products of distillation to the condensers, and its own gas main leading the non-condensable gases back to the kiln furnaces.

The condensers are composed of tall wooden tanks five feet square by twenty feet high, through which the products of distillation pass, each enclosing ninety-nine vertical copper pipes two inches in diameter through which the condensing water flows. The condensed products are trapped out at the bottom of each condenser, of which ten comprise a battery, and conveyed to cooling tanks where the tar is separated from the pyroligneous acid liquor by cooling. The tar is not at present distilled further, but is used to coat the kilns to render them impervious to air, and for this purpose one coating of tar suffices for four burnings while the usual coating of lime whitewash has to be repeated after each burning. The circulation of the gaseous products through the system is maintained by exhaust fans which draw the non-condensed gases through the condensers and force them through the gas main back to the kilns when they are injected into the furnaces by a steam jet from a $\frac{1}{16}$-inch orifice playing in the center of a one inch nozzle on the gas pipe. The minimum amount of air necessary to effect the perfect combustion of the gases is admitted through regulating dampers in the front of the furnace.

From the liquor coolers the pyroligeneous acid liquor is conveyed to

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the distilling house, where the acetic acid in the liquor is converted into acetate of lime; the liquor is then sent to the fractional distillation system which comprises eight primary stills and condensers, four intermediate stills and condensers and two final or shipping stills and condensers. The stills are circular tanks each holding about 2,500 gallons and are heated by steam coils of two-inch copper pipe. The several stills of each of the three series are operated abreast. The distillation is not carried on continuously, but each series is charged and the distillation carried on until all of the alcohol available is evaporated when the stills are emptied and recharged with new liquor. The degree of concentration attained in each series of stills is as follows:—

The liquor entering	the	primary	stills	contains	1½%	alcohol.
" distillate from	"	"	"	"	15%	"
"	"	"	the intermediate	"	"	42%	"
"	"	"	"	final	"	"	82%	"

In the final form the crude alcohol is sent to the refineries. The resulting product, methylic alcohol or hydrate of methyl (CH_4O) is of wide application in the arts, being extensively used as a solvent for gums and varnishes for which purposes varnish manufacturers report it from four to five times as rapid in action as grain alcohol.

Methylic alcohol has never been produced by fermentation but, judging from its mode of production in the charcoal kilns, its artificial production by synthesis may be inferred as possible. As none of the charcoal is sacrificed for carrying on the carbonization of the wood and as the action of the kilns during carbonization and cooling is under the control of the operator, it is reasonable to expect a larger yield of charcoal per cord of wood than in the common methods of burning in ground pits or common bee-hive ovens. The resulting charcoal is also better adapted to bear the burden in the blast furnace than the common charcoal, being both firmer and denser as is shown by the fact that while the average weight of common charcoal per bushel in Tennessee does not exceed sixteen pounds that made from the same varieties of wood by this process weighs twenty pounds per bushel. The following exhibit shows the comparative amounts produced by the common and the improved methods respectively:—

The average yield of charcoal per cord of wood in U. S.	= 38.1 bu.[1]
" " weight per bushel of 2,688 cu.in.	in U. S.	= 19.0 lbs.[1]
" " resulting ratio by weight of charcoal to wood in U. S.	= 18%
" " " " " " " " " "	in France	= 19%[2]
" " " " " " " " " "	in Belgium	= 16%[3]
" " " " " " " " " "	in Pyrenees	= 17%[4]
The resulting general average in above countries	= 17.5%
The average ratio by weight, charcoal to wood, by Pierce process	= 25.3%[5]

[1] U. S. Forestry Report, 1882.
[2] Sauvage. Ann. des Mines, 1837.
[3] Valerius. Traite de la Fabrication de la Fonte.
[4] Francois. Traitment direct des minerais de Fer.
[5] Result of seven years practice at different plants.

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The average ratio by weight, charcoal to wood, by Laboratory distillation, = 25.6%[1]

The resulting ratio of increase of Pierce process over average practice in the above mentioned countries = 44%

The resulting ratio of increase of Pierce process over average practice in U.S. = 33%

The quantitative values of the products resulting from the destructive distillation of the wood by this process are as follows, based on the proportion of the several varieties before given:—

DRY WOOD.	1.0 CORD.		4000 LBS.		100%
Resulting charcoal.....	50.6 bus.	1012 lbs.		25.3 %	
" methylic alcohol.....	4.4 gals.	30 lbs.		0.75%	
" acetic acid.....	4.6 gals.	40 lbs.		1.0 %	
" tarry compounds.....	16.5 gals.	160 lbs.		4.0 %	
" water.....	220.7 gals.	1838 lbs.		45.95%	
" non-condensable gases..	11000.0 cu. ft.	920 lbs.		23.0 %	
Totals.....	.....	4000 lbs.	4000 lbs.	100%	100%

The non-condensable gases are in excess of the amount required to effect the carbonization of the wood and about one-third of all produced are used for fuel under the boilers which produce steam for heating the alcohol stills, pumping water for the condensers, running the pyroligneous liquor pumps, the exhaust fans for the non-condensable gases and the winding engines for the cable incline cars used in raising the wood from the wharf-boat to the kilns. This drawing off of a portion of the gas produced and its burning under boilers furnishes, together with the escape of kiln gases during seasoning, the necessary outlet to prevent the undue accumulation of the non-combustible gases arising from the combustion in the kiln furnaces and the carbonic dioxide driven off from the wood both of which would otherwise continually accumulate in the circulation system and ultimately choke the furnaces.

From the standpoint of industrial economics, the question of the economical production of charcoal in large quantities is one of importance, since the charcoal industry is extensive and the lines of possible improvement on the common practice are promising. These directions of improvement evidently consist:

1. In increasing the present yield of charcoal per cord of wood.
2. In improving the quality of the charcoal produced.
3. In utilizing to the best economy all of the available products of the

[1] Experiments on same varieties of wood as are used in the Pierce process conducted by Stolze, Smith, Lattimore, Pierce, Aszmus and Hessel.

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destructive distillation of the wood of which the charcoal alone represents in value only about 35 per cent.

The total production of charcoal in the United States in 1887 was very approximately sixty-five million bushels; of this amount only about ten million bushels were produced by the process herein described and it is safe to assume that the production of all other improved processes combined did not make the aggregate of all charcoal produced by improved methods more than thirteen million bushels, or one-fifth the total production; on this assumption the following table has been prepared showing the returns to be expected from the general introduction of processes for charcoal manufacture which should equal in efficiency the results hereinbefore given. (See table, page 151.) This table shows not only the amounts of the several by-products annually preserved but also the annual saving in cords of wood carbonized and acres of forest land annually denuded if the present demands for charcoal were met by improved instead of unimproved processes.

This paper has been prepared independently of any effect its publication may have on the process herein described[1] and wholly for the purpose of showing by citing and describing one existing successful improved process that the common practice of charcoal burning is extremely wasteful, and that, instead of obtaining only charcoal and that moderate both in quantity and quality, it is possible to so effect the carbonization of the wood as that it shall not only furnish an increased yield of superior charcoal, but shall in addition supply the necessary fuel to haul itself to the kiln, to carbonize itself, to circulate and condense its gases and evaporate its liquors and shall furnish valuable chemical by-products whose proceeds more than pay the entire cost of all attendant operations and leave the charcoal as a clear profit to be divided between the producer and the consumer. A reference to the appended table shows that the general introduction of improved processes for the production of charcoal sufficient to meet the present demands would result in a saving of over four hundred thousand cords of wood per annum, a reduction of thirteen thousand five hundred acres in the amount of forest lands annually denuded or the liberation for other purposes of over four hundred thousand acres of land were the total supply of charcoal furnished from permanent timber preserves, and the preservation of by-products worth, at the lowest possible valuation, four million dollars per annum.

[1] The writer has no interest whatever either direct or indirect in the process herein described or in the publication of this paper which has been prepared without solicitation of any kind and solely from a belief that the account of the process might be of scientific interest.

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TABLE SHOWING GAINS TO BE REALIZED BY THE GENERAL INTRODUCTION OF IMPROVED METHODS FOR THE MANUFACTURE OF CHARCOAL.

	On the basis of total production by unimproved methods.	On present basis of one-fifth production by improved and four-fifths by unimproved methods.	On the basis of total production by improved methods.	Present gain by use of improved methods.	Possible gain by use of improved methods for total production.
No. of cords of wood annually required to meet present demands for charcoal	1,706,000	1,624,800	1,300,000	81,200	406,000
No. of acres annually denuded to furnish above amount assuming 30 cords per acre	56,870	54,160	43,330	2,710	13,540
No. of acres required to be set apart for charcoal preserves assuming growth of wood to be one cord per acre per annum	1,706,000	1,624,800	1,300,000	81,200	406,000
No. of gallons of wood alcohol at three gallons per cord	None	780,000	3,900,000	780,000	3,900,000
No. of tons of acetate of lime at 150 lbs. per cord	None	19,500	97,500	19,500	97,500
No. of barrels of tar at ten gallons per cord	None	52,000	260,000	52,000	260,000
No. of million of cubic feet non-condensable combustible gas at 4000 feet per cord	None	1,040	5,200	1,040	5,200

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ON THE INFLUENCE OF MOISTURE IN STEAM UPON THE STEAM CONSUMPTION PER LB. OF ENGINES OF LESS THAN FIFTY LBS. By. Prof. J. E. DENTON, Stevens Institute, Hoboken, N. J.

[ABSTRACT.]

THE paper describes an experiment with a 7 × 14 high speed engine in which water was injected into the steam pipe to the extent of about sixteen per cent of the total weight of steam used by the engine, and the resulting increase of steam consumption per lb. determined. It is shown that the increase in steam consumption was simply the water injected plus the latter's refrigerating effect in condensing steam with which it comes in contact.

The result indicates that the presence of moisture in steam does not induce a more uneconomical consumption of steam per lb. than is due to the amount of moisture itself; that is, does not increase the cylinder condensation of the engine, but further experiments are needed to establish a conclusion.

ON THE POSSIBILITY OF IDENTIFYING DRY OR SATURATED STEAM BY VISUAL OBSERVATION OF A JET OF SUCH STEAM FLOWING INTO THE ATMOSPHERE. By Prof. J. E. DENTON, Stevens Institute, Hoboken, N. J.

[ABSTRACT.]

THE paper describes an experiment in which a jet of steam flowing from a boiler at sixty pounds pressure into the atmosphere is superheated to a known degree, and then made to contain a known percentage of moisture by the abstraction of a known amount of heat from the jet.

Photographs were shown of the appearance of the jet of steam when the latter is dry, or slightly superheated, and when containing two and one-half per cent of moisture.

The conclusion reached is that as small an amount of moisture as one per cent causes a jet of steam to change in appearance to the naked eye so sensibly, that when a jet is perfectly transparent or invisible over a distance of about one inch from an orifice, which permits practically no wire drawing, it may be assumed that the moisture in the steam is less than one per cent.

RELATIVE ECONOMY OF HIGH SPEED ENGINES OF LESS THAN FIFTY LBS. USING STEAM BY EXPANSION AND THROTTLING RESPECTIVELY. By Prof. J. E. DENTON, Stevens Institute, Hoboken, N. J.

[ABSTRACT.]

THE paper gives the results of a series of experiments with a 7 × 14 high speed steam engine of the Buckeye type, whereby the steam consumption per horse power was determined for a large range of expansions at

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variable cut-offs, and for a range of throttling at fixed cut-off. The experiments were conducted so that the same effective horse power was obtained at ninety pounds boiler pressure and a speed of 265–284 revolutions per minute: (1) By expansion without the use of a condenser; (2) By expansion and the use of a condenser to produce eighteen inches of vacuum; (3) By throttling without a condenser; and (4) By throttling with 18″ vacuum.

Diagrams and tables showing the results obtained were shown. The conclusions reached are:

1. That for ratios of expansion between one and one-half and seven, there is but little variation of steam consumption per horse power.

2. That the use of a condenser reduces the steam consumption of the engine per horse power for all practical expansions.

3. That "throttling" results in a considerable loss of economy.

EFFECT OF FRICTION AT THE CONNECTING ROD BEARINGS ON THE FORCES TRANSMITTED. By Prof. D. S. JACOBUS, Stevens Institute, Hoboken, New Jersey.

[ABSTRACT.]

LET P_w and P_c be the pressures of the wrist and crank pins upon the rod for frictionless pins; P_{wf} and P_{cf} the same when there is friction; r_w and r_c the radii of the wrist and crank pins; R the length of the crank; nR the length of the connecting rod and tan φ the coëfficient of friction.

Friction displaces the forces which the pins exert upon the rod, so that they are tangent to circles respectively equal to $r_w \sin \varphi$ and $r_c \sin \varphi$. These forces will exert moments upon the rod tending to rotate it and therefore affect all the other forces of the system, so that the forces P_w and P_c become P_{wf} and P_{cf} and are altered from their original line of action.

By a well-known principle in mechanics a force applied at any point is equivalent to an equal force in magnitude and direction at any other point plus a moment equal to the force multiplied by the perpendicular distance through which it has been displaced. We may therefore suppose the forces P_{wf} and P_{cf} to be applied at the centres of the pins if at the same time we introduce the moments $P_{wf} r_w \sin \varphi$ and $P_{cf} r_c \sin \varphi$.

For convenience we will suppose each moment to be produced by a pair of equal and opposite forces acting perpendicular to the rod at the centres of the pins; calling these forces A and B we shall have:

$$AnR = P_{wf} r_w \sin \varphi$$

and

$$BnR = P_{cf} r_c \sin \varphi$$

so that the moment introduced will be

$$AnR + BnR = (A+B)\, nR$$

Now instead of supposing P_{wf} and P_{cf} to act in a line tangent to the circles $r_w \sin \varphi$ and $r_c \sin \varphi$ no error will be involved in determining the

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forces transmitted in the rod, if we suppose these forces to act at the centres of the pins, and introduce two additional forces A+B acting at the wrist pin perpendicular to the centre line of the rod and — (A+B) acting in an opposite direction at the crank pin.

The above reasoning may seem to involve a departure from the exact conditions of the problem, in which the forces are really applied in lines tangent to the circles $r_w \sin \varphi$ and $r_c \sin \varphi$, and it is the object of the paper to demonstrate that two such forces introduced into the solution for frictionless pins will give the correct results when friction is considered.

It is shown that P_{wf} and P_{cf}, as well as other forces such as the effort exerted on the crank, may be found with all desirable accuracy by employing the values of A and B found by the following approximate formula:

$$A = \frac{P_w r_w \sin \varphi}{nR} \quad \text{and} \quad B = \frac{P_c r_c \sin \varphi}{nR}$$

For instance in the case of a 10″ × 12″ horizontal, high speed engine, with the extravagant assumption of 25 % coëfficient of friction, these formulae give A + B within ½ of one per cent. and P_{wf} and P_{cf} will be true within $\frac{1}{500}$ and $\frac{1}{1400}$ of one per. cent respectively.

General solution of the transmission of force in a steam engine, including the action of friction, acceleration and gravity.

By Prof. D. S. Jacobus, Stevens Institute, Hoboken, N. J.

[ABSTRACT.]

This problem has been discussed by various writers at home and abroad but among the numerous contributions to the subject the writer has found none which attempt a general solution, either some limited purpose being kept in view, such as the proper stiffness of the connecting rod, or the forces necessary to accelerate it, or else the problem is restricted in various ways, from fear of making it too complicated, as for instance by unnecessarily simple hypotheses and needless approximations. Further than this some of the solutions are faulty.

At the last meeting the writer contributed a special case of this problem for the purpose of giving the correct expressions for the accelerating forces in an ordinary steam engine, and discussing their practical application in various special cases. At that time the general solution, though essentially complete, was not in finished form for publication, the calculations of numerical results in several practical cases are yet to be completed which will still further delay the complete publication of the article for a short time.

In the general solution of the problem the following conditions must be assumed:

(*a*) that the centre of the crank shaft is not in the line of travel of the wrist pin.

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re of gravity of the connecting rod is not in its line of

x revolves at a uniform speed.
ing parts have mass.
cts at any angle with the engine.
riction between sliding surfaces.
rmulæ include all of these conditions.

$$\theta + Z\Big\}$$

$$\frac{n-}{n} + \frac{c(\sin\theta - b)}{n\sqrt{n^2-(\sin\theta-b)^2}}\Big)\Big(\frac{l}{n}\sin\theta + \frac{o}{n}Z\Big) - \frac{\kappa^2}{n}\sin\theta\Big\}$$

$$\frac{l}{n} - \frac{c(\sin\theta - b)}{n\sqrt{n^2-(\sin\theta-b)^2}}\Big)\Big(\frac{l}{n}\sin\theta + \frac{o}{n}Z\Big) + \frac{\kappa^2}{n^2}\sin\theta\Big\}$$

$$\frac{-l}{} - \frac{c\sqrt{n^2-(\sin\theta-b)^2}}{n(\sin\theta-b)}\Big)\Big(\cos\theta + \frac{n-l}{n}Z + \frac{o}{n}\sin\theta\Big) + \frac{\kappa^2}{n^2}Z\Big\}$$

$$+ \frac{c\sqrt{n^2-(\sin\theta-b)^2}}{n(\sin\theta-b)}\Big)\Big(\cos\theta + \frac{n-l}{n}Z + \frac{o}{n}\sin\theta\Big) - \frac{\kappa^2}{n^2}Z\Big\}$$

$$\Big[\Big\{P_a + C - F_1 - H^1 + D\sin\delta - (A+B)\sin\beta - X_1\Big\}$$

$$\tan\beta + Y_1 + D\cos\delta - (A+B)\cos\beta\Big]$$

$$\overline{C - F_1 - H^1 - G_f\tan\varphi^1)^2 + G_f^2}$$

$$_1 - H^1 - G_f\tan\varphi^1 + D\sin\delta - (A+B)\sin\beta - X_1\Big\}$$

$$Y_2\cos\theta - X_2\sin\theta - (A+B)\cos(\theta+\beta) - E\cos(\theta+\delta)$$

$$_1 - H^1 - G_f\tan\varphi^1 + D\sin\delta - (A+B)\sin\beta - X_1\Big\}$$

$$Y_2\sin\theta - X_2\cos\theta + (A+B)\sin(\theta+\beta) + E\sin$$

$$\overline{G_f^2}$$

$$\Big\{\frac{1}{2}\Big\} - \frac{\sin\theta(\sin\theta-b)}{\sqrt{n^2-(\sin\theta-b)^2}}$$

$$\frac{+\delta)}{\beta)}\ W_2$$

re the mass, weight and accelerating force respectively
, and cross head.

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m W_2, and X_1, X_2, Y_1, Y_2 are the mass, weight and accelerating forces for connecting rod (1) for wrist pin and (2) for crank pin; also n R its length; c R, the perpendicular from its centre of gravity on its centre line; l R, distance of this perpendicular from the wrist pin; K R principal radius of gyration.

R is the length of the crank and τ its angular velocity, and b R a perpendicular from the centre of its shaft upon the path of the wrist pin; δ being the angle of this path with the horizontal.

r_w, r_c are the radii of the wrist and crank pins and tan φ the coefficient of friction, tan φ' being that of the cross head.

P_a is the total effective pressure of steam; H' friction of the piston and rod; G_f normal guide reaction; P_{wf} and P_{cf} pressures of the wrist and crank pins against the rod; N_f and T_f components of P_{cf} parallel and perpendicular to the crank; T_f' the latter reduced to the centre of the crank pin.

THE PANAMA CANAL AS IT IS. By Dr. WOLFRED NELSON, 348 Broadway, New York.

[This paper will be published in the author's "Five Years in Panama."]

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SECTION E.

GY AND GEOGRAPHY.

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ADDRESS

BY

GEORGE H. COOK,

VICE PRESIDENT, SECTION E.

ON THE INTERNATIONAL GEOLOGICAL CONGRESS, AND OUR PART IN IT AS AMERICAN GEOLOGISTS.

We meet here to-day as members of the American Association for the Advancement of Science. The wide extent of this field has made it necessary to consider science in separate divisions. Geography and geology have been assigned to us and we are required to do what we can to advance these two branches of the great subject.

What can each one of us do to help on the knowledge of these, our chosen subjects of study? It is hardly in place here to go over the advances which have been made in geography and geology during the last year. They have been many and important, but the public prints are so widely distributed that it would be only a twice-told tale to go over the subjects in detail. There are, however, some particulars to which it may be profitable to call your attention. This association, at the meeting in Buffalo in 1876, "appointed a committee" to consider the propriety of holding an International congress of geologists at Paris during the International exhibition of 1878, for the purpose of getting together comparative collections, maps and sections, and for the settling of obscure points, relating to geological classification and nomenclature.

Through the efforts and influence of this committee a congress was held in Paris in 1878, at which representatives from this country and from almost all the countries of Europe were present and took part in the proceedings, and the business of the congress as

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indicated above was fairly begun. A second meeting was held at Bologna, Italy, in 1881, at which some progress was made. A third at Berlin in 1885 and the points of business for the congress were somewhat further defined. A fourth meeting is to be held in London in September of this year and it is to be presumed that still further progress will be made in the two important subjects before it, classification and nomenclature.

But a meeting of the congress must be held in this country and American geology must be fully represented before any conclusions can be reached which will be accepted by the scientific world. At the meeting in London, an effort will be made to have the next meeting, that of 1891, held in this country. There is good reason to ask that a meeting be held here before the discussions on the important topics under consideration are closed. We think our field of observation an important one, better than that of any of the countries of Europe, and perhaps better than all combined. This was the opinion of the older geologists. William Maclure in his "Observations on the Geology of the United States of America," read before the American Philosophical Society in 1809 gives several reasons why geology can be best studied in America. Prof. Amos Eaton in 1828 quotes De Luc as saying that "the general strata must be settled in America where nature seems to have executed her works upon an enlarged scale." Such, too, is the opinion of some of our active geologists of the present day, whom if allowed, I might quote. But no argument on this subject is needed before this audience, nor will any be needed, to bring the International Geological Congress to the same conclusion, and we may look for it here three years from this time.

With this early notice of what is expected of us, it becomes us to make our preparations to show what we have done in geography and geology and to enforce their claims to acceptance, as part of the material to be used in providing for uniform classification and names. As a profitable way of beginning our work, we inquire What are the points in each of these sciences which are settled and what still remain to be worked out?

And first of GEOGRAPHY. This science, which has been the subject of study for all of us in our school-boy days, still needs great improvements. As a matter of civil geography, our country has suffered greatly in finances and we have come to the very verge of war, from an inaccurate knowledge and description of our bounda-

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ries. The northeastern boundary between the United States and Great Britain, described in the treaty of 1783, was remarkable for its inaccuracies of reference to rivers and highlands. It took twenty years to find out the river meant for the starting point and forty years more to find the highlands mentioned in the treaty, and the matter was finally settled by compromise in the Webster and Ashburton treaty of 1842. The boundary line between the United States and Mexico, as described in the treaty of Guadalupe Hidalgo in 1848, was equally inaccurate in its reference to places as they were laid down on an existing map which was appended to the treaty. There were errors of two or three degrees in the projection of the map, so that it did not conform to the topography of the country, and the text of the treaty could not be executed, and ten million dollars were paid to the Mexican government for the strip of territory needed to correct the inaccuracy of description.

The territory comprising the present states of New York and New Jersey was granted by Charles II to his brother James, Duke of York, in 1664, and the same year the Duke sold the portion named New Jersey to two English gentlemen. The partition line by which it was cut off, was probably described from a Dutch map of that time and gave the position and latitude of the two ends of the line which was to be a straight one. It was soon found that the latitudes were in error to the amount of almost twenty miles. This was the cause of litigation and strife for more than a hundred years. The line was finally established by a commission made up of the ablest surveyors from all the then colonies. The line was run and marked by monuments at the end of every mile. Now, however, it is found that no three of these are in a straight line, and taken as a whole, the middle of the line is nearly half a mile out from the line as defined.

Errors of the same kind are to be found in all the states surveyed before the present system of government land surveys was adopted; and they are still the cause of innumerable quarrels and lawsuits. It is true these are not the points of interest in our association, but they furnish most potent reasons for making accurate maps and they cause the supplies to be granted for making such maps,—maps with latitude and longitude accurately determined, and with topographic features correctly located, such as are essential to good work in geology. The forms of hills and mountains give clews to their origin and structure—the occurrence of

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gaps or depressions in ridges suggests searches for faults—breaks in the lines of ridges lead to examinations for offsets,—lines of rivers and of drainage lead to inquiries in almost every line of investigation. With a good topographic map before him a geologist can lay out his plans for attacking the different problems which are to be solved, or he can start his plan of the hypothetical structure of a region, and select the points he needs to study, in order to confirm or confute his hypothesis. Such maps are indispensable in laying down and describing the localities of the outcropping rocks which make up the geological series of the whole country. The work of making such maps, much as they are needed and imperatively as they are called for, is only just begun. The United States Coast and Geodetic Survey has long been engaged in determining the geographical positions of prominent points in the country bordering on the shores of the Atlantic, the Pacific and the Gulf of Mexico, and, as far as sustained, it has carried the work inland, and if properly supported it will carry its stations across the continent. Its results are attained with the greatest degree of accuracy and are recognized as authority in all countries where such surveys are made. As a basis for all reliable geographical surveys and descriptions, this work of the Geodetic Survey is needed now in all parts of our country and its prosecution should be urged as rapidly as possible.

Good work in the same line has also been done in the lake surveys by the United States government. Earlier surveys of the same kind were begun by the state of Massachusetts, and more recently New York has begun a state geodetic survey.

The accuracy with which surveys can be made is only beginning to be appreciated. One has only to go into the courts and learn of the disputes and litigation which have attended the older locations of boundaries and grants of land when errors of miles were frequent, while by modern methods positions can be fixed within a few inches, to understand the need there is for good work everywhere. And it is within the province of this association to exert all its influence to this end. In topography the making of surveys is only just begun. Topographic maps of New Hampshire were prepared under the direction of Prof. C. H. Hitchcock in 1874. Maps of Colorado and other western territories prepared under Dr. F. V. Hayden were published in 1877. The topographic map of New Jersey begun under the direction of the state geologist in 1877

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and continued since July, 1884, by the aid of the United States Geological Survey, is just completed and published. The topographic survey of Massachusetts begun by the joint action of the state and of the U. S. Geological Survey in 1884 is now approaching completion.

The United States Geological Survey began systematic work looking to a topographic map of the whole United States, several years since, and it is now in progress in different sections of the Union. The maps are being engraved in the best manner and issued as fast as they are completed.

There are other topographic maps of more limited districts, to which reference might be made, but those mentioned are sufficient to indicate the progress made in this direction. We are far behind the countries of Europe in respect to maps of the whole country—but it is believed that our later maps will not suffer in comparison with the best of those of foreign lands, and from some experience in directing such surveys, I feel warranted in saying that no public expense, incurred in carrying on scientific explorations, meets with such hearty recognition and approval as that for making and publishing such information in regard to the topographic features of the country in which we reside or travel. Such maps are invaluable to the civil engineer, to those watching over the public health, to those projecting works for water supply or for drainage, to those looking to the location of roads and railroads, to those seeking locations for rural homes, to those studying routes of travel on foot, by carriage or by bicycle, and they touch at some point or other the interest of every thoughtful or inquisitive citizen. Public money faithfully and judiciously expended in this direction gives encouragement to those controlling the public purse, to make liberal provision for the continuance of scientific works, and to aid in the investigation of the facts and principles which constitute the bases of all true science.

To us, however, geography is of most interest, because the forms and features of the earth's surface are so connected with the structure and materials which underlie it, that they furnish a guide to direct us in our geological studies, and a means of recording their results with accuracy and clearness. While there is much to be done, there is great encouragement to go on when the subject is progressing so satisfactorily.

GEOLOGY is revealing to us so many of its hitherto hidden treas-

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ures, that its study is being pursued with more ardor and intelligence than ever before.

Geology which treats of the structure of the whole earth, and which includes in its domain facts ascertained and principles deduced from all its parts, was first systematized from a very limited portion of the globe. It is not surprising, that a system arranged consistently with the facts in a single country should not be comprehensive enough to meet the circumstances of all others. American geologists began by transferring the German, English and French systems to this country. It took little time to find they did not fit the circumstances here, but with that reverence for authority which is due from the younger to the older, we have been trying to make our geology conform to theirs. The effort is only partially successful; and we have to admit, that something larger and more far-reaching must be devised before the science can be called a general one, applicable in all places.

It was probably some clear perception of this want in the science which led our fellow members to move for an international congress of geologists, and now it is our part to see where the deficiency lies, and to do what we can to make preparations for supplying it.

The time is so short since geology was first studied in any systematic way in this country, and the advances have been so rapid and so large that some consideration is needed before we can clearly define our present position and standing. It is within the lifetime of some of our still active geologists, that our first books on the subject were written. Maclure's "Observations on the Geology of the United States of America," begun in 1809, was first printed in its full form in 1817, and contains only about thirty pages of descriptive matter on American geology. It was, as Professor Silliman said, "a grand outline, drawn by Mr. Maclure with a masterly hand and with a vast extent of personal observation and labor." In 1818, Prof. Benjamin Silliman established the American Journal of Science and Arts, and in his introductory remarks he says "To account for the formation and changes of our globe by excursions of the imagination, often splendid and imposing, but usually visionary and almost always baseless, was, till within half a century, the business of geological speculations, but this research has now assumed a more sober character; the science of geology has been reared upon numerous and accurate observations of *facts;* and

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standing thus upon the basis of induction it is entitled to a rank among those sciences which Lord Bacon's Philosophy has contributed to create.

"The outlines of American geology appear to be particularly grand, simple and instructive, and a knowledge of the important facts and general principles of this science is of vast practical use as regards the interests of agriculture and the research for useful minerals. Geological and mineralogical descriptions, and maps of particular states and districts, are very much needed in the United States; and to excite a spirit to furnish them will form one leading object of the contemplated journal."

From this date onward the growth of American geology has been rapid and plainly marked. The American Journal itself, still in the charge of the family of its founder and supported by a corps of men representative in science, continues to be a repository of the advances of geological science. The Academy of Natural Sciences began the publication of geological papers the same year, and Prof. Amos Eaton published his first geological paper that year. It was a geological transverse section extending from Catskill mountain eastward to the Atlantic. Prof. Edward Hitchcock began the publication of his geological studies very soon after. The "Geological and Agricultural Survey of the district adjoining the Erie canal in the state of New York, accompanied by a Geological Profile extending from Boston to Lake Erie," by Prof. Amos Eaton, was published in 1824. The Geological Survey of North Carolina was begun by Denison Olmstead in the same year; that of South Carolina by Lardner Vanuxem in 1826; that of Massachusetts by Edward Hitchcock in 1832; that of Maryland in 1834 by J. T. Ducatel and J. H. Alexander. That of Tennessee by G. Troost in 1835. In 1836 surveys were begun in New York by Wm. W. Mather, Ebenezer Emmons, Lardner Vanuxem, Timothy A. Conrad and James Hall; in New Jersey by Henry D. Rogers; in Pennsylvania by Henry D. Rogers; in Ohio by S. P. Hildreth, and in Virginia by Wm. B. Rogers. In 1837 Charles T. Jackson began the survey of Maine and Jas. G. Percival that of Connecticut. In 1838 D. D. Owen began that of Indiana, and Douglass Houghton that of Michigan. Delaware was begun by Jas. C. Booth in 1839 and Kentucky by W. W. Mather in the same year. Rhode Island was begun in 1840 and New Hampshire in 1841 by Dr. Charles T. Jackson.

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The bare enumeration of these surveys and reports is enough to show the active interest in geology which had been developed in the country in those twenty-three years, both in the estimation of scientific men and in that of the public which authorized and encouraged the surveys. The men prominent in prosecuting the various surveys were able, enterprising and enthusiastic in their views of geology, both in its relations to science and to its economic applications. Their reports, now at the end of fifty years, are interesting reading and we wonder that so much good work could be done in a new and broad field, with such imperfect information to guide and with moderate financial support. The publication of these reports made it evident that men engaged in fields so remote from each other would be benefited in their work and relieved in their perplexities by conference with each other. On April 2, 1840, a meeting was held in Philadelphia and the American Association of Geologists and Naturalists was organized. Of the eighteen present, thirteen or fourteen were geologists fresh from the field. Nearly all have finished their work, though we are still permitted to see one of them,—Prof. James Hall, ripe in years, vigorous in health, and alive to everything which promotes the interests of the subject to which he has devoted himself for more than half a century.

The proceedings of the meeting, which was continued through a second and third day, are of interest to us, as showing the problems which occupied them, something of the questions then settled, and of those on which they sought information and advice. Professor Hitchcock exhibited specimens of "fossil footmarks so called." "This subject was of such interest as to induce the Association to appoint a committee to visit the localities and to report at the next meeting." Some persons had insisted that the *tracks* were only markings of some nondescript seaweed; but next year the committee, H. D. Rogers, Vanuxem, Taylor, Emmons and Conrad, reported that the views of Hitchcock were sustained by facts, and that the tracks were those of birds as he represented. Later discoveries have proved the then existence of Dinosaur reptiles, which were "biped in locomotion, like birds, seldom bringing their fore-feet to the ground." Some of them were three-toed, others four-toed, and still others five-toed. And the question involving so much of interest, and to some of feeling, is now settled in the minds of all geologists, the tracks are those of reptiles.

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At this first meeting there was a discussion on the subject of diluvial action. Information was communicated concerning diluvial grooves or scratches observed in the valleys of the Hudson, the Ohio and the Mississippi, on the polished limestones in New York, Pennsylvania, etc., and points were suggested for investigation. At the following meeting, W. W. Mather, who appears to have been of a committee on Drift, asked leave to defer his report to the next meeting. The subject, however, was ably discussed then, and the report of the discussion is very interesting showing, as it does, the interest it excited, and the many inquiries and investigations it had set in operation.

At the third meeting, the subject was a leading one before the Association. A very full and admirable paper was presented by Mr. Couthoy on the phenomena of icebergs, their movements, their agency in carrying earth and stones, and in disturbing the bottoms of shallow seas. A very full and carefully prepared paper was read by Professor Hitchcock on "The Phenomena of drift, or glacio-aqueous action in North America." His statement of facts was full and very fair, and approached as near to the glacial theory as could be done by one who had not visited glaciers and observed their phenomena. Charpentiér's work on glaciers, and the erratic deposits in the valley of the Rhone, was then but just published, and the masterly demonstrations of Agassiz on glaciers, their movement and effects were not completed when this meeting was held. It is not surprising that our geologists were slow in accepting this theory. There were no known glaciers in the country, and we had nothing in our observation from which to get a starting point. Gradually as more students have visited European glaciers, and their phenomena have been more studied, the theory has been accepted, and those who are still incredulous are a small minority. It has been the subject of many papers and much discussion in this Association; and, as would naturally be the case, the question has been most clearly presented and most convincingly settled in those parts of the country where the glaciated and the unglaciated surfaces come in contact. And if the doubters will visit the southern margin of the great terminal moraine and examine the surface where within a few feet one passes from the glaciated surface and the moraine of bowlders, gravel and drift-earth to the unglaciated surface and the plain where bowlders and mixed gravel are almost unknown, I cannot but think they will be convinced. The second

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question which has originated in later times, whether there was an earlier glacial formation than the one so well marked and which extended farther south, and that there was a long interglacial period between them, is answered in the affirmative by many. It is a question surrounded by many more difficulties than the first and I think needs more complete demonstration. It is worth the attention of our geologists and we may hope it will be settled before 1891.

Another question presented at the first meeting of geologists and naturalists was as to the origin of serpentine, whether strictly intrusive or metamorphic. The question has been much discussed since that time and some of its difficulties have been cleared up. Serpentine is now known to be a secondary product by chemical change and substitution of some of its elements, both in igneous and stratified rocks. It is in some cases not easy to assign it to its proper origin and each exposure of the rock in place has to be determined by its own characters and surroundings.

Other subjects of a more general character relating to agriculture and the arts were presented and discussed. It is a source of regret that a fuller report of the proceedings was not prepared and published; for this meeting marks an important era in the history of geological science in America. The conference gave new strength and courage to investigators; it introduced new men into the field; it began the work of combining and systematizing facts which were ascertained; and of providing for the newly discovered facts as they were brought forward. We owe a debt of gratitude to the men who took such pains to learn to do their work well and to transmit it in well arranged form to their successors.

Meetings were held by the Association in the successive years 1841 to 1847 inclusive, and it was then resolved into the American Association for the Advancement of Science, the first meeting of which was in 1848. The section of Geography and Geology, now section E of the American Association, is the representative of the society organized by American geologists to collate the individual work of each other, and to bring them into harmony of succession and name. It has already done much, and has reached the position from which it is prepared to do much more.

Many and perplexing questions have arisen in the progress of geology, some of which have taxed the powers of our ablest men; by continued efforts they are being solved. The Taconic ques-

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tion was really started as early as 1828 when Professor Eaton, in an article on Geological Nomenclature, in the Am. Jour. of Science, Vol. 24, p. 147, said "I have traversed the transition range from Massachusetts line to Hudson in fifteen places since the first part of this survey was published, for the purpose of ascertaining the true superposition of rocks in this most complicated and difficult geological theatre.

"The argillite under which the granular limestone passes near Massachusetts line, is certainly the very same continuous rock which forms the Cohoes falls and bed and banks of the Hudson from Baker's falls to Newberg near the Highlands. All the intervening rocks lie in a kind of inclined trough in the argillite. *We have no primitive argillite in our district, if organic remains form the characteristic distinction.* Neither do I believe there is such a rock as primitive argillite on this globe. This is Bakewell's opinion; and though I have often changed mine, I now believe he is correct, and that the basseting edges of the same rocks present a more primitive appearance in all cases; and that this fact has led geologists into ruinous errors."

These were the opinions reached by Professor Eaton; they vary somewhat from those presented by him in his report on the Erie canal rocks in 1824; but they were his matured conclusions and from them he never afterwards varied. He presented them strongly as became one who was thoroughly convinced of their correctness. At the end of sixty years we can now see for the ground he worked on, that he was right; and if he had known of some peculiarities of structure which have been worked out by his successors he could, with proper allowance for faults, have made a demonstration which would have saved a vast amount of time and labor. In 1842, Dr. Emmons presented his views of the rock structure of the country between western Massachusetts and the Hudson river and gave to the rocks the name of the Taconic system. This was in accordance with the teachings of Professor Dewey in 1820, Am. Jour., Vol. II, p. 246. This view was controverted by Dr. Emmons' associates in the New York Geological Survey and by many other prominent geologists; on the other hand it had the support of some, and the discussions on the subject have been earnest and well contested almost up to the present time. It is now conceded that the array of evidence brought by Prof. J. D. Dana, and later by Mr. Walcott, proves the case against Dr. Emmons and his Ta-

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conic system as first stated. The slates and limestones along the New York and New England boundary are of the Silurian age. Dr. Emmons, in his later work, did describe some rocks of the pre-Potsdam age, but they are on the western border or almost outside his original Taconic system of rocks. It now remains to assign the proper value to the name Taconic or to abandon it. Its originator was an able man and an industrious investigator. The questions he introduced were fair ones and have been well contested; if they have not been fully proved in the affirmative they have at least brought him no dishonor. In the progress of this discussion it appears that some of the difficulties attending the case arose from the different degrees of metamorphism in rocks of the same age and composition. Attention is now drawn more strongly than at any previous time to the need of a careful study of the metamorphic changes which rocks have undergone.

Prof. Henry D. Rogers, at one of the early meetings of the Association, brought forward the peculiar structure of the Triassic formation of New Jersey, Pennsylvania and the states farther south; a long and comparatively narrow strip with a monoclinal dip nearly at right angles to the length of the formation. The origin of this was to him a subject of curious interest, and his presentation of a theory to account for it, was a delight to those who could listen to his eloquent delivery. His theory was not satisfactory, however, and many have since tried their skill in the endeavor to solve the problem. It has been supposed that if longitudinal or northeast and southwest fractures, with an upthrow on the northwest side of each of them, could be found that they would explain the difficulty; but the rock is so nearly uniform in color and composition and so easy of disintegration that faults are hard to find, if they do exist. But it is believed that localities have been found where such faults can be shown and the fractured strata identified, both by mineral composition and by fossils. This removes another vexed question from the field and leaves the geologist to turn his attention to others that demand investigation.

Where to place the American Trias in the geological column is not settled. There are also further questions relating to the age of its igneous rocks, on which there is some difference of opinion; and the correlation of the Trias of the Atlantic slope with that of the middle and western portions of the continent needs much examination and study to bring it to a satisfactory condition. The

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materials collected by the geologists of the United States Geological Survey and by those of other government surveys have made large provision for such examination and now await the final arrangement.

The labors of Dr. Morton and others, early in 1834, demonstrated the existence of the cretaceous system in New Jersey and states farther south, and the study of its fossils in New Jersey, by them, has made that locality classic ground for studies in that member of the geological column. The developments there, though plainly and carefully worked out, comprise but a small part of the system as found in other countries. It is interesting to see the results of the explorations of later times as they have been continued at the south and in the great plains west of the Mississippi, in the Rocky mountains and in California. Each of these fields supplies some missing member of the series. The additions made are enormously large and seem to give all that is needed to make the system complete. The rocky structure of the country needs now to be studied to make sure that there are no repetitions of the rocks by great faults which sometimes increase the apparent thickness to a wonderful degree. Dr. White, in the last number of the American Journal, published his conclusion that the Laramie belongs in the upper part of the Cretaceous. At our meeting last year, Mr. Hill gave an account of the great additions to this system in the geology of Texas, and we have from Mr. McGee an account of a new addition to the lower portion of the Cretaceous in the vicinity of Washington which he names the Potomac series. With the scattered material which has been published in various reports and otherwise, there should be enough to show the fulness of the American series of that system.

In the Tertiary a good beginning was made early in the explorations of our Atlantic and Gulf borders, but those in the west and in the Rocky mountains are so much more extensive than any before known, and the fossils described are of such an extraordinary character, that it seems that a revision of the series, heretofore known, must be made so as to include the American developments.

Whether the Quaternary shall appear as a system in the list, or shall simply be considered as one of the Tertiary series is an unsettled point. If the systems are to be distinguished from each other by well and plainly marked changes in stratification or

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structure, then it is most likely the Quaternary will be only a system in that group.

In the International Geological Congress the two topics for examination and if possible for agreement are the general system of nomenclature, and the colors to be used in making geological maps. It is, however, perfectly obvious that before agreeing on names to be used, the objects to be named must first be agreed upon. And it is evidently from the lack of completeness in the geological column in any single country where the geology has been well studied and described, that the first difficulty arises. The order of succession of the rocks has been published, and names have been given to them, and now that these have been in use it is difficult to so change them as to make them a part of a scheme that shall be of universal application. It was this end which our Association aimed at in their resolution passed in 1876. And while progress has been made in the work at each meeting since held by the Congress, it is still in a very mixed condition. Great difficulties arise from the different languages spoken by the representatives of the several nations represented. In the Congress at Paris, in 1878, twenty different ones represented; in that at Bologna, in 1881, there were sixteen, and in that of Berlin in 1885, seventeen countries were represented. The language of the Congress is French, and all the representatives are required to present their subjects and communications in that language. Of course all foreigners are at a disadvantage,—and many are hopelessly so. Another difficulty arises from unequal representation. The attendance is voluntary, the members pay their own expenses, and the time and money required must hinder many who are deeply interested from attending the meetings, and this hindrance is greater in proportion as the distance from the place of meeting increases. The attendance shows this; at the Paris meeting there were 194 Frenchmen and 110 foreigners, at the Bologna meeting 149 Italians and 75 foreigners, and at the Berlin meeting 163 Germans and 92 foreigners. This it will be seen does not give general geology a fair representation, when questions come up which are to be decided in favor of the majority voting on them. Such votes can only be tentative, and the decisions will hardly be acquiesced in until a more equable representation is brought to act upon the unsettled questions, and many more countries have been fully represented. They do, however, bring out the questions upon which action is to

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be taken, and prepare the way for a right decision. The Congress at Berlin aimed to embody the present condition of European geological science, and cartography by preparing a map of Europe in which the legend gave all the larger known divisions of the geological column, and the colors on the map showed their locations. The following tabular statement gives the results they had reached at the time of the Berlin meeting in 1885. It is taken from the Report of Dr. Persifor Frazer, Secretary of the American Committee of the International Geological Congress, who was present and took part in the meeting. I copy only the classification and nomenclature, and omit the part relating to color.

The presentation of this tabular statement gives opportunity to examine the various parts separately; allows those who make particular portions of it their study, to fill up its deficiencies and those who are in any way questioning its truth to nature, to make criticisms and corrections. It will be seen that the stratified Terranes are all included in five divisions which go from the more general to those which are more specific.

Those of the

First	order	are	named	Groups,	and	their	times	are	Eras.
Second	"	"	"	Systems	"	"	"	"	Periods.
Third	"	"	"	Series	"	"	"	"	Epochs.
Fourth	"	"	"	Stages	"	"	"	"	Ages.
Fifth	"	"	"	Beds	"	"	"	"	?
Sixth	"	"	"	?	"	"	"	"	?

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SEDIMENTARY TERRANES.

TIME DIVISIONS.

1st order. ERA.	*2nd order.* PERIOD.	*3rd order.* EPOCH.	*4th order.* AGE.	*5th order.* ?

STRUCTURAL DIVISIONS.

GROUPS.	SYSTEMS.	SERIES.	STAGES	BEDS.
Cenozoic.		Present deposits (alluvial, etc.)		
		Quaternary (diluvium)		
	Tertiary.	Pliocene,		
		Miocene,		
		Oligocene,		
		Eocene.		
Mesozoic.	Cretacic.	Upper Cretacic,		
		Gault,		
		Lower Cretacic (Neocomian),		
		Wealdian.		
	Jurassic.	Malm,		
		Dogger,		
		Lias.		
	?	Rhœtic.		
	Triassic.	Upper Trias (Keuper)		
		Middle Trias (Muschelkalk)		
		Lower Trias (variegated sandstone).		
?	?	Zechstein,		
		Permian.		
Paleozoic.	Carbonic.	Coal Measures,		
		Lower Carbonic (Culm),		
	Devonic.	Famennian,		
		Eifelian,		
		Rhenan.		
	Siluric.	Upper Siluric,		
		Lower Siluric,		
		Cambrian.		
Azoic.	Archæan.	Azoic Schists (Phyllites),		
		Crystalline Schists,		
		Gneiss, etc.		

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There was strongly expressed opposition to the order of the terms *groups* and *series*, a very respectable minority preferring to have them transposed and to call divisions of the first order *series* and those of the third order *groups*, and this action may yet be taken. The names of the several groups are well settled by present usage, though the French and some other nations preferred the still older names of Primitive, Primary, Secondary and Tertiary; and as they are well settled in our language they might be reinstated without difficulty.

The divisions of the second order, *systems*, are the same with those now in general use. The attempt is made to have the names all end in *ic* and is successful except in the first and last ones. It will be seen that no agreement was reached in regard to the proper location of the dividing line between the Jurassic and Triassic systems, the Rhœtic series being the subject of difference. It is doubtful whether it is distinctly recognized in American geology. And in the cases of the Zechstein and Permian, there was such decided difference of opinion as to their proper connection with the Triassic or Carbonic systems that the decision was deferred. Our American geologists, Hall and Newberry, who were present, stated that, as far as now known, the decision would not affect the division of the American series, no representatives of the Permian having been found in the United States. The clearest sentiment, as expressed, was rather in favor of joining them to the Carbonic system.

As far as divisions of the first and second order are concerned, it appears as if uniformity of practice in marking the divisions, in giving names and in using colors for maps are concerned, a conclusion could soon be reached. But in the divisions and names of the third order, as they now stand in the Proceedings of Congress, there will need to be much further investigation and conference. But the free and wide fields of research and discussion must certainly bring out the truths now wanting in order to fill out the blank places in the series. The extension of work over wider fields is constantly filling the great gaps which are so marked in narrower fields, and are leading to the conclusion that while sedimentation has ceased for a time in some localities, it has at the same time been going on in others; and so the passage from one division to another may finally be shown to be an almost inappreciable one.

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As it stands now in this list of names we are reminded of the remarks of Whewell made more than fifty years ago, that the advancement of three of the main divisions of geological inquiry has during the last half century been promoted successively by three different nations of Europe, the Germans, the English, and the French. The systematic study of what may be called mineralogical geology had its origin and chief point of activity in Germany, where Werner first described with precision the mineral characters of rocks. The classification of the secondary formations, each marked by their peculiar fossils, belongs in a great measure to England, where the labors of Smith, and those of the most active members of the Geological Society of London, were steadily directed to these objects. The foundation of the third branch, that relating to the Tertiary formations, was laid in France by the splendid work of Cuvier and Brongniart, published in 1808, "On the Mineral Geography, and Organic Remains of the Neighborhood of Paris."

"We may still trace, in the language of the science, and our present methods of arrangement, the various countries where the growth of these several departments of geology was at different times promoted."

With the great accessions which have been made to the general stock of geological knowledge, by American geologists, and the general publication of it, it becomes necessary that this should be incorporated in a work which is designed to be comprehensive enough to take in the geology of the world. This list of names for the members of the series undoubtedly satisfied the Europeans who voted upon them, but they are too local, too geographic, too strange to have a place in any general series. Names must be given in describing new kinds or occurrences of rocks, but they should be provisional, and dropped whenever some more characteristic or generally appropriate name can be found. For calling attention to the several divisions, these names will be very useful, and by their general publication they can be brought to the consideration of hundreds of working geologists, who by their contributions and suggestions can throw light on the subject, though they may never be able to attend an international geological congress. The advancement of science in modern time is brought about much more by the increased number of workers in the cause than it is by the greater attainments of a few men. With attention properly

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drawn to this position of geological science, with a great body of workers in the field, with an immense territory in which to work,—and with a notice of three years in advance, we can prepare the case so as fairly to present the claims of American geology to a representation in a general system of geology. The Congress went no farther in the lists of names: those of the fourth, fifth and sixth order will be still more difficult to generalize, and it may be that it will be found expedient to leave the names of these orders to be given in the languages of the countries where they find their application.

It might tend to a more equitable representation of the views of members from different countries, if the number of votes to which each country should be entitled, could be equitably settled, and the representation from each country should be in some way controlled by the whole body of geologists; but in a country like ours, where most geologists have active duties to discharge in the milder seasons when meetings are held, this cannot always be had. Besides, the work calls for an individual sacrifice of money and time which many persons think they cannot properly make either for the public good, or for the benefit of science.

These are difficulties which attend the present arrangements for work; and at present I can only bring them to your attention without offering any suggestions for their solution. The objects of the Congress are worthy and useful ones, and they will be attained. To us they give direction and point to our investigations and studies, and they will be profitable by leading us to a fuller examination of the whole field of geological science as well as to a more careful and demonstrative study of special fields in which our individual work lies.

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PAPERS READ.

THE DISCOVERY OF SPOROCARPS IN THE OHIO SHALE. By Prof. EDWARD ORTON, Columbus, Ohio.

[ABSTRACT.]

AT the Montreal meeting, I described to the members of section E the occurrence in vast numbers of microscopic spores in the shales of Devonian age in Ohio and adjacent states. I have recently obtained a new line of facts in regard to these interesting bodies, in the discovery of the *sporocarps* or the vessels that contained these spores.

In 1868, Sir Wm. Logan noted the occurrence of certain fossils which he characterized as "microscopic, orbicular" bodies in the Upper Erian shales of Kettle Point, Lake Huron, but he made no further reference to their occurrence for a number of years. In 1869, he called the attention of Principal (Sir J. William) Dawson to these bodies, and the latter afterward described them in his report on the Erian flora of Canada (Geol. Surv. of Can., 1871) under the name of *Sporangites Huronensis*. He counted them the spores of acrogenous plants and presumably of *Lepidodendron primævum*, the remains of which he found in the same beds.

In the April number of the Amer. Journal of Science for the same year, Principal Dawson called further attention to these forms, noting their resemblance to certain fossils from Brazil described by Carruthers as *Flemingites*, and also to fossils from the white coal of Australia.

These shale fossils had been meanwhile rediscovered and studied elsewhere, viz., as they occurred in the bowlder clay underlying Lake Michigan where the tunnel for the water supply of Chicago was driven. Dr. H. A. Johnson and B. W. Thomas, Esq., studied them, figured them, and sent them to distinguished microscopists of this country and Europe without however obtaining a clew to their real nature. The occurrence of the spores in the city water of Chicago was also noted by Mr. Thomas.

In 1879, without knowledge of the previous discoveries, I found these fossils once more, in the drillings of a deep well, 800 to 1000 feet below the surface, in Kingsville, Ohio. I made no advance in my knowledge, however, for two years, but at the end of this time, I came upon them again

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and learned for the first time their universal distribution through the entire shale formation of Ohio, Kentucky, Indiana and Michigan. By correspondence with Sir Wm. Dawson, I learned of his priority in the discovery and interpretation of these fossils. I adopted his name of course, but the facts presented in my paper at the Montreal meeting led him, as he says, to revise his conclusion as to the origin of the spores and to suspect their derivation from some group of aquatic plants lower than the Lycopods.

Professors H. S. Williams and J. M. Clarke contributed some facts as to the occurrence of these bodies in the shales of New York.

The next step in advance was taken in 1883 by Sir Wm. Dawson. He received at that time from Brazil, through Mr. O. A. Derby, specimens which threw new light on the whole investigation. Sir William had previously received *Sporangites* from that country in collections made by Professor Hart, but Mr. Derby's specimens afforded not only the spores, but the envelopes in which they were contained, which occurred as oval sacs. These sacs were found by Sir William to resemble very closely the sporocarps of *Salvinia*, a member of a somewhat insignificant group of acrogens, known as rhizocarps. The name *Protosalvinia* was accordingly brought in to displace the earlier designation, viz., *Sporangites* and we now have five forms referred to the new genus. The original form, *P. Huronensis*, occurs in vast numbers throughout the entire series of the Ohio shales.

In April, 1888, the next advance was made in our knowledge of these forms by the discovery made by one of my students, C. J. Welch, E.M., of sporocarps in the shale series of Columbus, Ohio. The first found were flattened, circular discs, about 4 mm. in long diameter, composed of thick walled, carbonized cells, beautifully reticulated in structure; but, presently, a new and distinct form, elongated and furcated, was found by Mr. Welch, which has been named by Sir Wm. Dawson, *Sporocarpon furcatum*.

Both forms are found in great abundance in certain phases of the shale formation and new light is promised by them as to the rhizocarpean vegetation from which they are derived.

Newberry's suggestion that we owe the black shales to a Sargasso sea was a fruitful one, matching the facts better than any other theory of origin. At last, we see the kinds of vegetation that mantled these land-locked basins of the early days. It did not consist of algæ, but belonged to a higher division of the vegetable kingdom, viz., the rhizocarps. It is thus seen to be closely allied to the divisions of plants that were covering the land at this time with a wonderful growth of ferns, Lycopods and Calamites.

The vegetable kingdom is divided into two main groups, viz., Phænogams and Cryptogams. The first is by far the more important at the present time. To which do we owe the great accumulations of the stored sunpower of the past as found in coal? To the latter division. But the Cryptogams are broken up into three main series, viz., Acrogens, Anogens and Thallogens. To which of these is the work of coal accumulation due?

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Mainly, to the Acrogens. The latter are subdivided into the following families: *Lycopods*, *Ferns*, *Scouring-rushes* and *Rhizocarps*. From which of these is the coal flora derived? Mainly, from the first three.

There is left a single division that lacks prominence at the present time, but which we are now following back to a widespread development and to a most important service. The highest office of the vegetable kingdom consists in its storing up the power of the sun. The two permanent forms of stored sun-power are coal and petroleum. Both of them, we owe to acrogens, coal to the terrestrial, and petroleum to the marine representatives of the class. The shale series which we have been considering is as unmistakably the great source of the accumulations of oil and gas in Pennsylvania and New York as the carboniferous formation is the main source of coal.

THE NEW HORIZONS OF OIL AND GAS IN THE MISSISSIPPI VALLEY. By Prof. EDWARD ORTON, Columbus, Ohio.

[ABSTRACT.]

IN the epidemic of drilling deep wells that has swept through the states of the Ohio valley during the last five years, a vast store of facts of great geological importance has been brought to light and some of them are also immensely important on the economic side. In all this work it is the unexpected which has happened.

Four or five horizons from which oil and gas are derived on a large scale have been added to those already known.

1. The first in value is the Trenton limestone. This is at the present time the most prolific single source of bituminous products in the entire country. Wells reaching down to it yield a maximum of thirty million cubic feet of gas per day and maintain their flow for months and years without unusual reduction. Wells also are found in it that produce 5000 barrels of oil in a day and that keep up their flow until totals of more than 100,000 barrels are credited to single wells. The largest connected gas territory in the world derives its supplies from this horizon. The structure of the new fields is so simple and easily read that important light is being thrown upon the problem of gas and oil accumulation everywhere from the facts that obtain here.

The porosity of the rocks, upon which its storage capacity depends, is due to a dolomitization of 5 to 50 feet of the uppermost beds of the stratum. To the imperfect interlocking of the dolomitic crystals, the storage chambers of the gas and oil are due. The areas in which this replacement has taken place can be pointed out. Most of the territory is, of

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course, occupied by salt water, but in the domes or terraces where relief is furnished, the bituminous products are gathered.

In production, every foot of relief in the storage rock proves effective. The spirit level gives, in most instances, a good explanation of the behavior of different wells.

The depth of the reservoir is found to be a function of the rock-pressure of the gas or oil. All the facts seem to show that this rock-pressure has an artesian origin, taking its rise in the salt-water that lies behind and below it. The latter element is thus seen to be an essential one in every region of high-pressure gas.

As to the present production of the Trenton limestone it is only necessary to say that many hundred million cubic feet of gas are surging forth every day throughout no less than 8000 square miles of territory in Ohio and Indiana. Upon this enormous production of light and heat and power, a vast manufacturing interest is being rapidly built up, which is certain to work revolutionary changes in many interests. The supplies have been wasted in a most extravagant way, but they will last long enough to shift the centres of manufactures to quite an extent.

The gas is piped with great success to cities forty miles distant from the fields while the oil is carried as far as Chicago in pipe lines, to become the basis of a very important fuel-supply.

The production of oil is repressed as far as possible by bringing down the price to fifteen cents per barrel. In spite of this effort, 20,000 or more barrels are brought to the surface every day, and a price of thirty cents per barrel would bring 100,000 barrels to the surface every twenty-four hours, within ninety days.

2. The well-known stratum, the Clinton limestone, proves to be a gas and oil rock of considerable value in Ohio under suitable conditions of relief. The most important gas supply of the Clinton is found at Lancaster. It is probably to this horizon that the Glasgow production of southern Kentucky is due.

3. The Canada oil horizon is shown by the sections that approach it from Ohio and in Michigan, to be in no way connected with the Corniferous limestone as has heretofore been asserted, but it is buried in the great series of Onondaga-Lower-Helderberg age, presuming these two formations, viz., the Onondaga salt group and the Lower Helderberg limestones, to be of one and the same age, but standing for different conditions of growth.

4. The Ohio shale has recently been found to be a source of high-pressure gas in western Kentucky. If anything could be counted settled as to the gas production of a particular formation, the facts as to the Ohio shale might have been so considered, but most of the experience of the Ohio field in regard to it has been set aside by the facts to which reference is here made. Owing to a porosity that the formation has acquired through some of the accidents of its history, it becomes in Meade county, Kentucky, a true reservoir rock, its gas pressure being determined by a salt-water column as in all other true reservoir fields.

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THE CRETACEOUS DEPOSITS OF NORTH AMERICA. By Dr. CHARLES A. WHITE of the U. S. Geological Survey.

[ABSTRACT.]

THIS paper comprised a portion of work upon the cretaceous deposits of North America which Dr. White is preparing for publication. When completed it will appear as a Bulletin of the United States Geological Survey and it is therefore only briefly noticed in this volume.

It gave an outline of his proposed work and, by way of illustrating the method of its execution, the paper included that portion of the work which relates to the cretaceous deposits of the Atlantic coast region. The immediate incentive to the preparation of this work is the pressing need of a revised scheme of classification of the geological formations of this continent which shall receive at least the conventional approval of all leading geologists. It is, however, intended that the work, although only a concise summary of what is now known of this subject, shall be of more than temporary use.

For convenient treatment of his subject the author divides the continent geographically into regions and provinces, which divisions are in part natural and in part arbitrary. He will attempt to correlate all the sections of North American cretaceous strata that have been published by different geologists which will exhibit the synonymy of the different formations and their equivalents which have thus arisen.

ON THE OCCURRENCE OF THE "FOREST BED" BENEATH INTRA-MORAINIC DRIFT. By FRANK LEVERETT, U. S. Geological Survey, Madison, Wis.

[ABSTRACT.]

THE region under discussion is a portion of northeastern Illinois which is crossed by a series of moraines of the Lake Michigan glacier, older than the moraines described by Prof. T. C. Chamberlin in the Third Annual Report of the U. S. Geological Survey (though recognized and indicated in part by dotted lines) and since studied by the writer under the direction of Professor Chamberlin.

The "Forest Bed" exhibits a variety of phases: peat, muck, soil, wood, etc. It has been found by well-borings, and samples of these borings have been examined by the writer.

1. *Geographic Distribution.* There are three main belts: (1) Near Mendota, Illinois, over an area about twenty-five miles in length and two to four miles in width, beneath the inner slope of a morainic ridge, at a depth of sixty to one hundred and forty feet, the distance from the surface increasing with the elevation. (2) In the "Iroquois artesian well district"

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in Iroquois and portions of adjoining counties (Vermillion, Champaign, Ford, McLean and Livingstone), over a known area of at least five hundred square miles. It is most frequently encountered beneath the till plain on the inner slope of the moraines which sweep around the artesian well district, at a depth of sixty to one hundred and ten feet, but is occasionally penetrated beneath moraines in Livingstone, McLean and Ford counties and is found along the outer border and slopes of moraines in Vermillion and Champaign counties. (3) In McHenry and Kane counties in the midst of a series of morainic ridges at depths varying from sixty to one hundred and eighty feet; the depth increasing with elevation.

2. *Stratigraphic Distribution.* It occurs both as an interglacial soil between tills, and below all the tills as if preglacial. Nowhere have more than two beds been penetrated in the same well section and usually but one occurs.

The "Forest Bed" is known to be *in situ:* (1) By a leached subsoil. (2) By underlying sand beds containing molluscan shells. The subsoil has been found in the Mendota area leached to a depth of two to four feet, beneath which there is a calcareous till. The fossiliferous sands occur in abundance in the Iroquois area.

We have, in this vegetal bed, evidence of an interglacial vegetation having spread farther north than the south border of the *morainic* drift, showing that when these moraines were formed, the ice sheet had made an advance and that the moraines cannot be considered mere halting places in the retreat of the ice sheet.

RECENT DISCOVERIES OF ROCK-SALT IN KANSAS. By ROBERT HAY, Assistant, U. S. Geological Survey, Junction City, Kansas.

[ABSTRACT.]

THE examination of salt marshes and salt springs in northern middle Kansas caused Professor Mudge, more than twenty years ago, to suggest that rock salt would be discovered in that region. Wells and borings of considerable depth in the coal measures of eastern Kansas and of the so-called Permo-carboniferous strata have yielded abundant streams of salt water. The discovery of *rock gas* in the eastern counties has recently stimulated speculative drilling in all parts of the state. The prospector's drill at Ellsworth, in August, 1887, struck *rock salt* at a depth of seven hundred and thirty feet. Before the end of the year rock salt had been pierced by the drill at Kingman, Hutchinson, Lyons and Anthony. A previous boring had shown salt shales at Caldwell. The beds of salt—there is more than one at each of these places—vary from twenty to one hundred et in thickness and they are accompanied by and intercalated f salty shales, and, in one instance, beds of limestone. At

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Anthony and Kingman the surface rocks and all the way down to the salt the strata are of Triassic age. At Hutchinson these are overlain by one to two hundred feet of the alluvia of the Arkansas valley. This is also true at Sterling where salt has been reached, July, 1888. At Lyons the red beds (Trias) are also covered with alluvia and possibly some tertiary deposits. At Ellsworth, the Dacotah formations are well developed and the triassic red beds that were there had never before been suspected, for to the northeast the Dacotah formations rest on the Permo-carboniferous, yet in Kingman and Barber counties reduced thicknesses of the Dacotah rest on eroded red beds. But at Ellsworth, the salt is, as elsewhere, at the bottom of the red beds. In the region where the Dacotah is in contact with the Permian, a well marked gypsiferous horizon is found among the Upper Permian beds. In several of the salt borings a gypsiferous horizon is found from sixty to four hundred feet below the lower limit of salt in Permian strata.

The *salt rock* and accompanying saliferous shales form a *saliferous horizon* from three to five hundred feet thick, passing upward from the Permian into the Trias, apparently without break.

At the close of the Permian age, depression of the northeastern area was arrested and uplift commenced while south and west the sinking continued and the saliferous horizon and red beds were deposited all in shallow seas. The northeastern area was depressed to take, on its eroded surface of Permo-carboniferous strata, the earliest Dacotah formations; and the southern and western area was at that time elevated and eroded, becoming again depressed in time to extend the Dacotah area in that direction in some of its upper beds, including the lignite. The axis of oscillation has not yet been made out about which these movements turned, but it would seem that here we have unbroken succession from the Upper Carboniferous to the Dacotah on neighboring areas, through the saliferous and triassic rocks.

In Barber county and to the west and south in the Indian Territory is another gypsiferous horizon in the Upper Triassic strata. It is not impossible that the salt plains of the Cimarron and the salt pool in Meade county may be indications of another saliferous horizon above this.

Kansas is going into the manufacture of salt on a large scale. At Kingman a shaft is being sunk to mine the salt. At Ellsworth, Lyons, Anthony and Sterling works are in progress of which the output will vary from one hundred and fifty to four hundred barrels per day. Hutchinson has already salt blocks in operation whose output reaches 1500 barrels per day, and others in progress which will treble that quantity. It is expected, within a year or two that Kansas salt will be the only salt sold west of the Mississippi river.

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THE DISCOVERY OF FOSSIL TRACKS IN THE TRIASSIC OF YORK COUNTY, PA. By ATREUS WANNER, York, Pa.

[ABSTRACT.[1]]

THE author of this paper announced that he had recently found fossil tracks and plants, probably algæ, in the trias of York Co., Pa. A slab from this newly discovered locality of Miamelchnites was sent, by Mr. Wanner, to the National Museum in January, 1888.

Professor Hitchcock in commenting on the above paper, stated that he had seen the slab in the National Museum, and that he recognized upon it three species of Dinosaurs, belonging to the genus Anomœpus; also a probable species of Anisopus; all of them closely related to species of those genera long known in Massachusetts. These impressions, he stated, had not been seen south of the Delaware river in New Jersey and Pennsylvania prior to their recent discovery by himself.

He also added that he had a large amount of matter concerning footmarks in his possession, mostly descriptions of new species from Connecticut and New Jersey, which he hoped to make use of in a *Revision of Ichnology*. The time had come for a restatement of the facts of this science, and the investigations into the character of tracks made by living animals which were commenced by the late President Edward Hitchcock, thirty years since, will be continued by his son. The study of the tracks of crustacea was entered upon in January and February, 1888, in Florida. It was found that a considerable similarity exists between the amphipods and isopods and such genera as *Acanthichnus*, *Bifurcalipes*, *Hexapodichnus* and *Climacodichnus* of the Ichnology of Massachusetts. The discovery of *Cheirotherium* from Pennsylvania was announced by the writer in 1868. Additional specimens have since been found at Milford, N. J., now belonging to Lafayette College, Easton, Pa., which show a front foot of ornithic aspect. There seems to be a close relation between this supposed *Cheirotherium* and the *Otozoum* of New England. Other specimens supply needed information about the giant *Polemarchus*.

THE OIL FIELDS OF COLORADO. By Prof. J. S. NEWBERRY, Columbia College, New York.

[ABSTRACT.]

THE only oil field at present productive in Colorado is in the valley of the Arkansas about Florence, a new and growing town, thirty miles above Pueblo. The geology of this region is all Cretaceous. The table-lands bordering the Arkansas valley are composed of the shales and sandstones of the Laramie group which contain valuable seams of coal now largely mined at Coal Creek near Florence for the supply of Pueblo, Denver and the Prairie country toward the east.

The Arkansas river cuts through the Laramie exposing the top of the

[1] The paper will be printed in the Report of the State Geologist of Pennsylvania.

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Colorado group; here for the most part dark bituminous shales which have been proved, by boring, to be over 3000 feet in thickness. The oil emanates from the depth of from 1200 to 1500 feet from the surface. About forty wells have been bored within a radius of two or three miles about Florence. Nearly all have yielded oil, but in very different quantity; from two or three up to one hundred and twenty barrels per day. Fourteen wells are now being pumped and the average product is about sixty barrels to the well; so that the present aggregate yield of the wells is about one thousand barrels per day.

The oil is of very excellent quality, light green in color, having a gravity of about 31° Beaumé and has rather an agreeable odor. When distilled it yields 40% of burning fluid and nearly 60% of lubricating oil. The burning fluid is "water white" and has almost nothing of the pungent odor which characterizes our Eastern kerosene. The lubricating oil is of better quality than that furnished by the Pennsylvania wells. It contains so large an amount of paraffine that it becomes pasty at zero temperature. This is a slight objection to its use in the natural state, but is a fault which can be easily corrected whenever the weather becomes cold enough to make it necessary.

The origin of the oil can hardly be a matter of doubt. It is produced by the spontaneous distillation of carbonaceous shales as is the oil of western Pennsylvania, though the geological ages are very different. All the productive territory in the Arkansas oil field is controlled by a syndicate called the Union Oil Company. It owns the land or oil right over more than fifty thousand acres and could apparently increase the production of oil to any desired extent. Now the burning fluid supplies the markets of all the Rocky Mountain region from Montana to Mexico, but the sale of the lubricating oil is prevented by artificial competition. Many thousand barrels are stored and it will ultimately find an outlet by way of the Gulf of Mexico if other channels are closed to it. At present it is only used for fuel under the stills and the boilers of the pumping engines. It is blown into the furnaces with a jet of steam and is a model fuel, but its consumption in this manner is a great sacrifice as it is intrinsically much the most valuable product of the wells.

THE AGE AND CORRELATION OF THE MESOZOIC ROCKS OF THE SERGIPE-ALAGÔAS BASIN OF BRAZIL. By Prof. JOHN C. BRANNER, State Geologist of Arkansas, Little Rock, Ark.

[ABSTRACT.]

IN his "Contributions to the Paleontology of Brazil," Dr. C. A. White describes the mesozoic fossils collected by the author in the Sergipe-Alagôas basin of Brazil. Upon the evidence offered by these fossils Dr. White refers the Sergipe beds to the Cretaceous. He admits, however, that some

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of the species have a jurassic aspect, though none of them are identifiable with known jurassic species. Professor Alpheus Hyatt was also struck by the jurassic aspect of some of the cephalopods brought from this region by Professor Hartt in 1869. The author calls attention to the fact that of three beds yielding fossils, and from which collections were most complete, one of them lying at the base of the three, yields most of the fossils of jurassic aspect, an overlying bed yields fossils of cretaceous aspect alone, while the uppermost bed again yields fossils of cretaceous and jurassic aspect.

In referring the beds of this basin to the Cretaceous Dr. White says that while such a conclusion would, he thinks, have been reached from a study of the fossils alone, much reliance has been placed on the corroborative testimony of the geologists of the Brazilian Survey. We have no stratigraphic evidence whatever, throwing light upon the age of these beds. The overlying deposits have been referred to the Tertiary simply because they do overlie these deposits which have been referred to the Cretaceous. Underlying beds have been referred to the Paleozoic, but without any paleontologic evidence.

THE AGE OF THE CRYSTALLINE ROCKS OF ARKANSAS. By Prof. JOHN BRANNER, State Geologist of Arkansas, Little Rock, Ark.

[ABSTRACT.]

GEOLOGICAL maps of the United States represent a small area about Little Rock, Arkansas, and another small area in the southwestern part of the state as Archæan. A recent examination of the crystalline rocks of these and other similar regions in Arkansas shows that none of these rocks are Archæan. They have all been injected into paleozoic strata, and have branching dykes penetrating overlying beds from the principal masses. The exact age of those crystalline rocks has not been determined, for the paleozoic beds into which they were injected have been so completely metamorphosed that they retain no paleontologic evidence of their age. On account of their stratigraphic relations I am inclined to refer most of these sedimentary and metamorphic rocks to the Lower Carboniferous.

THE PERIDOTITES OF PIKE COUNTY, ARKANSAS. By Prof. JOHN C. BRANNER, and R. N. BRACKETT, Little Rock, Ark.

[ABSTRACT.]

DR. OWEN in the second volume of his Geological Reports on Arkansas mentions a small area of igneous rock in Pike county. Geological map-makers appear to have referred this rock to the Archæan. Recent

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examinations of the rock and the locality by the senior author show it to have been injected and through lower cretaceous beds. Its mineral composition and structure show it to belong to the new type of peridotites, picrite porphyry, or kimberlite of H. C. Lewis. This is the third occurrence of this rock reported in the United States, the first having been that of Elliott county, Kentucky, described by Mr. Diller; the second that of Syracuse, New York, described by Dr. G. H. Williams. It differs somewhat from the rocks of either of the other localities. It contains no enstatite like the Kentucky rock, its pyroxenic constituent being augite. It contains no ilmenite, but has perofskite in great abundance. It has less fresh olivine than that from Kentucky. There is a total absence of rhombic pyroxene.

THE DISTRIBUTION OF THE GRANITES OF THE NORTHWESTERN STATES AND THEIR GENERAL LITHOLOGIC CHARACTERS. By Prof. C. W. HALL, University of Minnesota, Minneapolis, Minn.

[ABSTRACT.]

THE paper mentions the following as the situation of the granites occurring in Michigan, Wisconsin, Minnesota and Dakota: in Michigan frequently throughout the Marquette and Menominee iron-bearing districts; in Wisconsin in various localities within the so-called Laurentian area of that state, an area which comprises much of the northern central portion with a few outliers in the Huronian and Keweenawan areas; in Minnesota (1) in several belts along the Canadian boundary projecting southwesterly into the state; (2) quite prominent masses, whether connected with those along the boundary or not, around Vermillion, Snowbank and other lakes; (3) the great Mesabi; (4) the exposures of central Minnesota in Stearns, Sherburne, Benton, Morrison and Mille Lacs counties; in Dakota in the southerly and southwesterly portions of the Black Hills.

These granites are either intrusives or granitic veinstones. The veinstones constitute a very insignificant part of these rocks unless it be in the Black Hills where, as Crosby has recently pointed out, there are vast quantities of this material. In Minnesota and Wisconsin granitic veins seldom exceed a few feet in width.

The intrusives which make up the remainder of this great class of rocks have as a group the following general characters:

(1) A coarseness of texture when the Concord or the Barre granite of New England is taken as a type. This frequently passes into a porphyritic structure.

(2) An excessive proportion of the feldspars in their composition; orthoclase, microcline and a plagioclastic feldspar, sometimes oligoclase and sometimes labradorite, are always present.

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(3) The presence of quartz in two modifications: (*a*) in segregated area composed of very large individuals and (*b*) in streams and clusters of mi nute granules sometimes forming a cement between the quartz, feldspa and other constituents and sometimes saturating these minerals as a sec ondary product.

(4) The almost universal presence of hornblende as one of the basi constituents and from which the biotite is shown in many instances to b derived.

(5) The presence of a pyroxenic constituent, augite or diallage, i many of the fresher granites situated as a core within the hornblende area and concluded to be the source of the hornblende which mineral is doubt less wholly secondary.

So far as the question of age can enter into the discussion of the pape it is the writer's opinion that being intrusive the granites have been in truded at various times between the formation of the Laurentian floor o the continent and the close of the agnotozoic era. They as a rock specie may be regarded as the product of one of the three or four grand period of eruptive activity which the intrusive rocks of the northwestern state represent.

ON THE INTENSITY OF EARTHQUAKES, WITH APPROXIMATE CALCULATION OF THE ENERGY INVOLVED. By Prof. T. C. MENDENHALL, of Ros Polytechnic Institute, Terre Haute, Ind.

As an exact science, seismology is in its infancy. Although great prog ress has been made during the past ten years, and especially in the deve opment of instruments and methods for a more precise study of seismi phenomena, the results thus far have served rather to reveal the compl cated nature of the problems involved; and while encouraging the seismo ogist to renewed effort they warn him that his labors are not to be ligh The recent advances of the science have been, and properly, toward th study of the phenomena at hand, the nature and extent of the motion o the earth particle together with the rate at which the disturbance is pro agated, in the expectation and hope that in time the location and charact of the original cause may be revealed through these.

In the early growth of an exact science one of the obstacles met wit is the absence of an exact nomenclature, and seismology furnishes n exception to this rule. Whenever it becomes desirable or necessary to i corporate the meaning of a word in a mathematical expression it is impe ative that the necessary restrictions be placed upon its use. It has lon been customary to speak of the *intensity* of an earthquake without an special effort to give the word an exact meaning. Generally it is a plied to the destructiveness of the disturbance on the earth's surface, an

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sometimes to the magnitude of the subterranean cause of the same. But modern seismology proposes to measure the intensity of an earthquake and to express its value numerically. It is worth while, therefore, to inquire in what sense the term may be used with precision and what may be accepted as its mathematical equivalent. Evidently it may mean, and in fact it has been made by different writers to mean, the measure of the surface destruction; the energy per unit area of wave front of a single earthquake wave; the rate at which energy is transmitted across unit of area of a plane parallel to the wave front; and the total energy expended in the production of the original disturbance. The use of well constructed seismographs has furnished us, within a few years, a good deal of fairly reliable information relating to certain elements of earthquake motion, notably the amplitude and period of vibration and the velocity of transmission, by means of which, and aided by a few not very violent assumptions, some of the above quantities may be calculated. They are not identical, numerically or otherwise, and it is manifestly improper to apply the word *intensity* to all of them.

An earthquake wave is generally assumed to be the result of an harmonic vibration, while this supposition is not strictly correct, it is probably not so far erroneous as to materially vitiate the results which follow.

If then,

a = maximum displacement.

t = periodic time.

v_1 = maximum velocity of particle.

V = velocity of wave transmission.

d = density of material through which transmission occurs.

The following are easily obtained:

(1) Maximum velocity, $v_1 = \frac{2\pi a}{t}$.

(2) Maximum acceleration, $\frac{v_1^2}{a} = \frac{4\pi^2 a}{t^2}$.

(3) Energy of unit volume with velocity, $v_1 = \frac{1}{2} d v_1^2 = \frac{2\pi^2 a^2 d}{t^2}$.

(4) Energy of wave per unit area of wave-front $= \frac{2\pi^2 a^2 d V}{t}$.

(5) Energy per second across unit area of plane parallel to wave-front (rate of transmission) $= \frac{2\pi^2 a^2 d V}{t^2}$.

It is well known that Mallet and others of the earlier seismologists attempted to find a mathematical expression which should represent the so-called "intensity" of the shock, by means of the velocity of projection of loose bodies as determined by their range, and also through the dimensions of bodies which would be overturned by the shock. The maximum velocity of the earth might be ascertained by the first method with fair accuracy; the second method is nearly, if not quite worthless in practice, and both are decidedly inferior in design and operation to the modern seismograph which gives the principal elements of the motion directly.

In a paper by Professors Milne and Gray, Philosophical Magazine, Nov.

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1881, the following occurs: "The intensity of a shock is evidently best estimated from the maximum velocity of translation produced in a body during an earthquake. This is evidently the element according to which the destructive power is to be measured, it being proportional to the maximum kinetic energy of the bodies on the earth's surface relative to that surface during the shock." Now this statement is inconsistent with that which immediately follows and with their mathematical expression which is

$$I \propto \frac{A}{T^2},$$

equivalent to the second expression given above. This inconsistency was doubtless quickly and first detected by the authors and in a copy of the paper received from them I find interlinear corrections in the paragraph quoted above in virtue of which the words "rate of change of" are substituted for the word "maximum" where it first occurs, and "acceleration" for the words "kinetic energy," thus bringing it into agreement with the remainder of the discussion, and at the same time unquestionably better representing the opinion of the authors, who in all subsequent publications have used the maximum acceleration to represent the intensity as shown in the overturning, shattering and projecting power of the shock.

The same expression, $\frac{v_1^2}{a}$, is used as a measure of intensity by Professor Holden in his paper on "Earthquake intensities in San Francisco,"[1] where he defines it as "intensity of shock defined mechanically = destructive effect = the maximum acceleration due to the impulse." He asserts that "the researches of the Japanese seismologists have abundantly shown that the destruction of building, etc., is proportional to the acceleration produced by the earthquake shock itself, in a mass connected with the earth's surface." This statement is hardly justifiable, at least up to the present time. In the Report of the British Association for 1885, the committee appointed by the association for the purpose of investigating the earthquake phenomena of Japan, consisting of Messrs. Etheridge, Gray and Milne, describe among other seismic experiments one which consisted in determining the quantity to be calculated from an earthquake diagram which would give a measure of the overturning or shattering power of a disturbance. The result of this investigation seemed to show that the acceleration, which by calculation from the dimensions of the columns was necessary for overturning, was somewhere between the mean acceleration, represented by $\frac{4v_1}{t}$ and the maximum acceleration, $\frac{v_1^2}{a}$.

The actual destruction caused by an earthquake wave is undoubtedly a function of many variables, but it seems tolerably certain that maximum acceleration is the leading factor and at the present time no better measure can be found. It appears to me, however, that it is unwise to apply the term "intensity" or "intensity of shock" to this quantity, which might be called the "destructiveness" of the wave, or perhaps, its "destructivity" as indicating a little more clearly the power to destroy.

[1] Am. Journ. Science, Vol. XXXV, page 427.

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Dutton and Hayden in their "abstract of the results of the investigation of the Charleston earthquake" presented to the National Academy of Sciences on April 19, 1887, define intensity as the "amount of energy per unit area of wave-front," but in the subsequent discussion use it almost continually as a measure of surface destruction. Upon the first definition they have based a very interesting and novel method for determining the depth of the focus; but in the application of the method to the Charleston earthquake they have used the word in its other and very different sense. A reference to the formulæ given above will show that one of these quantities is inversely as the square of the distance from the origin, as assumed by them in the development of their method, while the other, used in its application, is not so proportional and this must be admitted to be fatal to their deductions.

In the discussion of a somewhat analogous case, Lord Rayleigh says,[1] "the rate at which energy is transmitted across unit of area of a plane parallel to the front of a progressive wave may be regarded as the mechanical measure of the intensity of the radiation." The algebraic expression for this quantity, as shown above, is, of course, similar to that of the quantity last considered, differing from it only in the power of "t" in the denominator. Both are very important expressions; neither is very closely related to "surface destruction" and the latter is unquestionably a suitable measure of the "intensity of an earthquake" in the most important sense.

It thus appears that at least four measures for earthquake intensity are and have been in use, which are expressed mathematically in terms of amplitude, period, velocity of transmission and density of medium in formulæ (1) (2) (4) (5) above. To show more forcibly the necessity for placing some restrictions upon the use of the word, I have compared the "intensities" of two earthquakes, using each of the four expressions. The disturbances compared are those of May 6 and May 11, 1884, at Tokyo, Japan, the observations being made by Professor Milne.[2] The same instrument, located in the same place, was used in both and the interval of time between the two is so small as to forbid any important change in the conditions. That of May 6 is called "A" and that of May 11 "B." The results are as follows:

$\frac{B}{A}$ —	(1)	(2)	(4)	(5)
	1.1	1.7	.9	1.3

from which it is evident that much depends on the measure of intensity adopted.

As stated in the beginning of this paper, the more recent work of seismologists has been in the study of individual disturbances for the purpose of determining the principal elements of motion, amplitude, period, direction and speed of transmission. In this study much has been learned. From the nature of the case we are almost absolutely restricted to an investigation of surface phenomena and we are soon forced to admit that

[1] Lord Rayleigh, Theory of Sound, Vol. II, page 16.
[2] Trans. Seis. Soc. Japan, Vol. X, page 27.

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what goes on at the surface cannot accurately represent what is going
below. Among other reasons for this conclusion we have notably
greatly varying results obtained from the same disturbance at points co
paratively very near to each other. The amplitude at one point may
two or three times that at another a few hundred feet away and not o
this but the periodic times do not agree, and when the measure of ma
mum acceleration is applied to the disturbance, its so-called intensity
destructiveness will vary greatly within a small area. As a matter of f
it has long been known that such variations in destructive power do
cur in nearly all earthquakes. Not only do the above elements vary,
the speed of transmission, when once the surface is reached, is undou
edly not constant, although we have no reason to believe that it is
approximately so in the rocks through which it is, in the main, tra
mitted. Most of these irregularities are doubtless due to the non-elas
character of the materials lying near the surface and to their lack of
mogeneity. In spite of their appearance in the phenomena of the surf
it is difficult, if not impossible, to believe that they exist in the rocks belo
It is more reasonable to assume that during an earthquake the waves
transmission are, in the main, and until the surface is reached, somew
regular in their form and approximately constant in certain of their e
ments. It may also be assumed that in amplitude and periodic time
subterranean wave, although doubtless much less than the surface wa
cannot differ from it enormously, so that elements of motion obtained
seismometric observations upon the surface, may be applied within c
tain limits to the investigation of the energy involved, the results be
considered as rough approximations.

On these assumptions the following calculations have been made:

Let A be the area of a portion of the wave-front and l a length measu
at right angles to A. Then formula (5) above, which shows the ene
per second across unit area, multiplied by $\frac{Al}{V}$ will evidently express the
ergy required to generate the waves existing at any moment in the volu
lA. That is

$$\begin{aligned}
&\frac{2\pi^2 a^2 d}{t^2} V \cdot \frac{Al}{V} \\
&= \frac{2\pi^2 a^2 d}{t^2} Al \\
&= \frac{2\pi^2 a^2}{t^2} \cdot m \quad (m = \text{mass of volume } lA) \\
&= \tfrac{1}{2} m v_1^2
\end{aligned}$$

That is to say, the work consumed in generating waves of harmonic ty
is the same as would be required to give the maximum velocity to
whole mass through which the waves extend.[1] Sir William Thomso
who was probably the first to apply this principle, in his calculation
the mechanical value of a cubic mile of sunlight, concludes that in
case of a complex radiation this value is more likely to reach twice th
of the above expression.

[1] Lord Rayleigh, Theory of Sound, Vol. II, page 17. Sir William Thomson on "
Possible Density of the Luminiferous Medium."

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On the assumption that the maximum velocity of the particle is known we may now apply this formula to the calculation of the energy involved in an earthquake. For this purpose I have selected first, the Japanese earthquake of January 15, 1887, which disturbed over thirty thousand square miles of territory and the elements of which were well recorded on the Tokyo seismographs. Assuming a mass of 150 lbs. per cubic foot and taking a cubic mile as the volume to be considered, I find that to put it in vibration required the expenditure of 2,500,000,000 ft. lbs. of energy, and this might be called the "mechanical value of a cubic mile of earthquake." Assuming that an area of one hundred miles square with a mean depth of one mile was thus in vibration at any one instant of time, which is not improbable considering the known rate of transmission and the long duration of the earthquake, the amount of energy thus represented would be 25×10^{12} ft. lbs. This energy might be generated by the fall, under the action of gravity, of a cube of rock one thousand feet on each edge, the mass of which would be 75,000,000 tons, through a vertical distance of about 166 feet.

It would be interesting to apply this method to the Charleston earthquake of August 31, 1886. Unfortunately no seismographic records were made and the elements of motion are largely matters of conjecture. Messrs. Dutton and Hayden in the report already referred to express the opinion that in some localities the displacement must have been as much as ten inches or one foot. This seems to me improbable, but it may be safe to say that over a considerable area it was as much as one inch. Nothing is known with certainty as to the period of the oscillations, but as it generally increases with the magnitude of the disturbance it would probably not be grossly incorrect to call it two seconds. Assuming these magnitudes I find the energy of a cubic mile of the Charleston earthquake, taken near enough to the epicentrum to be disturbed as above, to be equal to 24,000,000,000 ft. lbs. The speed of transmission of this disturbance has been pretty well determined by Newcomb and Dutton, to be approximately three miles per second, so that a cubic mile would be disturbed in one-third of a second. To do this would require 180,000,000 horse power. Assuming as before that an area about the epicentrum one hundred miles square was thus disturbed the energy involved would be 24×10^{12} ft. lbs., and the rate of its expenditure would be that of 1,300,000,000,000 horse power.

All of these numbers can only be regarded as gross approximations. They probably indicate the order of magnitudes involved and may be useful until more reliable data are furnished.

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AN ANCIENT CHANNEL OF THE OHIO AT CINCINNATI. By Prof. JOSEPH F. JAMES, Agricultural College, Maryland.

[ABSTRACT.]

CINCINNATI is built upon a terrace of the Ohio river as have also been many other cities of the western states. The Ohio is one of the streams which has cut for itself, in part of its course, a new channel. Part of the old bed is now known as Mill Creek, a small stream emptying into the Ohio below Cincinnati. It is an insignificant stream, occupying a channel excavated by a much larger river. The bed of the ancient river is of great importance to Cincinnati, inasmuch as by its means many railroads have access to the city. Without this valley, tunnels or inclined planes would have been necessary to enable the railroads to enter the city.

The surrounding hills are of the solid blue limestone of Lower Silurian age, quarried so extensively for building stone and for lime. The hills were once continuous across the river to the mouth of the Licking from Price's Hill, but the Ohio has forced a passage through them. The edges of Mill Creek valley are of rock, but the bottom is sand, gravel and clay. Far beneath lies the bed rock. At the foot of George street, in Cincinnati, the drift is forty-eight feet thick; at Cumminsville, the rock is sixty feet below low water in the Ohio. In another case, one hundred and twenty feet were penetrated before bed rock was reached. At Ivorydale, ninety-eight feet of gravel overlie the rock. At Hamilton, twenty-five miles north of Cincinnati, the gravel is two hundred and fourteen feet thick. Thus, the rock here is ninety-one feet below low water in the Ohio river, so that there is a descent in the rocky bottom of Mill Creek from Cincinnati to Hamilton *below* the ground, while at the surface Hamilton is one hundred and twenty-three feet higher than Cincinnati.

In consequence of the barrier across its channel at Cincinnati, the Ohio once followed the present valley of Mill Creek north to Hamilton, at which point it was joined by the Big Miami. Together the streams flowed southwest and entered the present channel of the Ohio at Lawrenceburg.

At the east end of Cincinnati is the wide mouth of the Little Miami river. For a distance of two and a half miles no rock is exposed at the surface, though the whole country is covered by huge banks of drift fifty and one hundred feet high. Where this drift now is, was the ancient channel of the Ohio, and if followed up this channel is found to unite with the western arms of the Ohio north of Cincinnati near Ludlow Grove. To still further prove the existence of this ancient channel is the fact of the bed rock being exposed in the channel of the Ohio at and below the mouth of Mill Creek, while above this point it is covered by sixty feet and more of gravel and sand.

After the glacial period the river forced its way over or through the barrier which had previously existed below Mill Creek and cut a new channel, the present one, for itself. It found its previous channel choked up with débris and had to make for itself a new but not so extensive a channel as the old one.

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NOTES ON THE ORIGIN AND HISTORY OF THE GREAT LAKES OF NORTH AMERICA. By Prof. J. W. SPENCER, University of Georgia, Athens, Ga.

[ABSTRACT.]

Discovery of the ancient course of the St. Lawrence River.

PREVIOUS investigations by the author showed that there was a former river draining the Erie basin and flowing into the extreme western end of Lake Ontario, and thence to the east of Oswego, but no further traceable, as the lake bottom rose to the northeast. Upon the southern side there was a series of escarpments (some now submerged) with vertical cliffs facing the old channel. By recent studies of the elevated beaches, it is demonstrated that the disappearance of this valley is due to subsequent warpings of the earth's crust, and that the valley of the St. Lawrence was one with that of Lake Ontario. Recent discoveries of a deep channel, upon the northern side of Lake Ontario (a few miles east of Toronto), and of the absence of rocks to a great depth under the drift, far beneath the surface of Lake Huron, between Lake Ontario and the Georgian bay,— and in front of the Niagara escarpment, between these lakes,— of a channel in Georgia bay, at the foot of the escarpment, and of the channel across Lake Huron, also at the foot of a high submerged escarpment, show that the ancient St. Lawrence during a period of high continental elevation rose in Lake Michigan, flowed across Lake Huron and down Georgian bay and a channel, now filled with drift, to Lake Ontario; thence by the present St. Lawrence valley to the sea—receiving on its way the ancient drainage of the Erie basin and other valleys.

Origin of the basins of the Great Lakes.

The two questions involved are the "origin of the valleys" and the "cause of their being closed into water basins." The basins of Lakes Ontario and Huron are taken for consideration. The previous paper, upon the course of the ancient St. Lawrence, shows that the Huron and Ontario basins are sections of the former great St. Lawrence valley, which was bounded, especially upon the southern side, by high and precipitous escarpments, some of which are submerged. Upon its northern side there were lesser vertical escarpments, now submerged, with walls facing the old valley. The valley was excavated when the continent was at a high altitude, for the eastern portion stood at least 1,200 feet higher than at present, as shown by the channels in the Lower St. Lawrence, in Hudson's straits and the New York and Chesapeake bays. The valley was obstructed in part by drift and in part by a north and northeastward differential elevation of the earth's surface, due to terrestrial movements. The measurable amount of warping defied investigation until recently, but it is now measured by the uplift of the beaches and sea cliffs. Only one other explanation of the origin of the basins need be considered — that of the "Erosion by Glaciers," (*a*) because the lake basins occur in glaciated re-

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gions; (*b*) glaciers are considered (by some) to erode; (*c*) supposed n cessity, as the terrestrial warping was not known.

In reply: living glaciers abrade but do not erode hard rocks, and bot modern and extinct glaciers are known to have flowed over even loos moraines and gravels. Again, even although glaciers were capable of gre plowing action, they did not affect the lake valleys, as the glaciation the surface rocks shows the movement to have been at angles (fro 15° to 90°) to the trend of the vertical escarpments against which t movement occurred. Also the vertical faces of the escarpments are n smoothed off as are the faces of the Alpine valleys, down which the gl ciers have passed. Lastly, the warping of the earth's surface in the la region, since the beach episode, after the deposit of the drift proper, nearly enough to account for all rocky barriers which obstruct the o valley and form lake basins.

Establishment and dismemberment of Lake Warren.

This is the first chapter in the history of the great lakes and is subs quent to the deposit of the upper boulder clay, and therefore the lakes a all very new in point of geological time. By the warping movemen of the earth's crust, as shown in the beaches — after the deposit of t later boulder clay — the lake region was reduced to sea level and the were no Canadian highlands northward of the great lakes. During t subsequent elevations of the continent, beaches were made around t rising islands. Thus between Lakes Erie, Huron and Ontario, a true bea was formed at 1690 feet above the sea, around a small island rising 30 fe higher. With the rising of the continent, lake (or perhaps gulf of) Warr — a name given to the sheet of water covering the basin of all the gre lakes—was formed. A succession of beaches of this lake have been work out in Canada, and from Lake Michigan to New York, extending ov many hundreds — almost thousands —of miles. Everywhere the differe tial uplift has increased from almost zero, about the western end of t Erie basin, to three, five, and, in the higher beaches, more feet per mi With the successive elevations of the land this lake became disme bered, as described in the succeeding papers — and the present lakes h their birth. The idea that these beaches in Ohio and Michigan were he in by glacial dams to the northward is disproven by the occurrence open water and beaches to the north, which belong to the same seri and by the fact that outlets existed where glacial dams would be quired.

Discovery of the outlet of Huron-Michigan-Superior Lake into Lake Ontar by the Trent Valley.

With the continental elevation described in the last paper—owing to t land rising more rapidly to the northeast—Lake Warren became disme bered and Huron, Michigan and Superior formed one lake; the Erie bas was lifted out of the bed of Lake Warren and became drained, and O tario remained a lake at a lower level. The outlet of the upper lake w

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southeast of Georgian bay by way of the Trent valley into Lake Ontario, at about sixty miles west of the present outlet of this lake. The outlet of this upper lake was 26 feet deep where it connected with the Trent valley, and the channel was from one to two miles wide. This, for a few miles, is cut across a drift ridge to a depth of 500 feet. With the continued continental uplift to the northeast (which has raised the old beach at the outlet, into the Trent valley, about 800 feet above the present surface of Lake Huron), the waters were backed southward and overflowed into the Erie basin, thus making the Erie outlet of the upper lakes to be of recent date. This is proven by the fact that the beach, which marked the old surface plain of the upper great lake, descends to the present water level at the southern end of Lake Huron.

Erie the youngest of all The Great Lakes.

The Erie basin is very shallow, and upon the dismemberment of Lake Warren was drained by the newly constructed Niagara river (except perhaps a small lakelet southeast of Long point). Subsequently the northeastward warping (very much less in amount than farther northward at the Trent outlet) eventually lifted up a rocky barrier and formed Erie into a lake in recent times, thus making Erie the youngest of all the lakes. The beaches about Cleveland are not those of separated Lake Erie, but belong to the older and original Lake Warren.

NOTE.—To distinguish from the modern, the ancient valley of the St. Lawrence, above described, is named the "Laurentian;" the ancient river from the Erie basin, the Erigan; the Huron–Michigan–Superior lake, the Algonquin, as also the beach which marked its shores, and the river which discharged its waters by the Trent valley. The expanded, but separate, Lake Ontario is named the Iroquois, as also its principal beach, now at 116 feet above its modern surface, at the extreme western end of the lake, while at about 135 miles northeastward (near Trenton) its elevation is 435 feet.

REMARKS ON AN UNDESCRIBED VEGETABLE ORGANISM FROM THE FORT UNION GROUP OF MONTANA. By Prof. LESTER F. WARD, U. S. Geological Survey, Washington, D. C.

[ABSTRACT.]

THE specimens were collected in 1883 at two points forty miles apart and on opposite sides of the Yellowstone in the vicinity of Glendive, Montana. At one of the localities, viz., Iron Bluff, twelve miles above that town and on the right bank of the river some fifteen meters above low water mark, it occurs in a red burned cliff in light arenaceous clay, the specimens being very large, sometimes measuring thirty centimeters across. At the other locality, namely Burns' Ranch, twenty-eight miles below Glen-

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dive on the left bank of the river and close to the water's edge, the specimens are smaller and more perfect, being embedded in a fine grained bluish clay shale. The fossil shows a large circular center 2–7cm. in diameter from which there proceed in radial arrangement in all directions a large number of single flexible stems varying in length and having a width of 2–3 mm. These horizontal, radiating stems are sometimes slightly sinuous, lying upon and often crossing one another. They exhibit for most of their length, beginning near their attachment to the center, a row of toothlike appendages on each side, which are about ½mm. in width at the base and about 1mm. apart, obliquely ovate in shape with obtuse tips and always projecting forward toward the distal end of the stem at an angle of 50°. Close examination with a high power reveals the presence of a continuous epidermal membrane composed of hexagonal cells connecting these projections. The stems are uniform in width and not marked by any longitudinal costa until within some 3cm. of the apex when they expand into an elongated elliptic blade, or head, terminating the stem. Through the center of each of these heads run two rows of what appear to be spore-cases, one on each side of the median line and separated from each other by a very narrow interval forming a continuous groove running longitudinally through the head. The supposed spore-cases are somewhat elongated transversely, and arranged in pairs, filling most of the surface of the head, but leaving a winged expansion at the central or widest portion. They average 1½mm. in length and ½mm. in thickness. Below the base of the head, where the teeth begin, they appear to cease, but in most cases a careful inspection reveals their presence in an obsolete and probably functionless form, and this is sometimes distinguishable for considerable distance down the stem where it assumes more the aspect of a series of articulations widening as the center is approached. The lateral teeth of the stems usually cease below the head, but cases occur in which they continue for some distance along the margins of the expanded lamina.

Considerable, but not as yet exhaustive, search has been made through the literature of paleontology to find the analogues and determine the affinities of this singular organism, as yet almost entirely without success, the forms figured under the names Discophorites, Gyrophyllites and Tænidium, perhaps having the greatest resemblance, but not close enough to indicate any relationship. Specimens have been shown and sent to a number of eminent paleobotanists and paleontologists, but none, so far as heard from, can give any idea of its nature. Its vegetable character having been questioned it has also been shown or sent to the best authorities on invertebrate zoology in this country and in Europe. Those who have thus far expressed an opinion have uniformly denied its relation to any known animal. It is remarkable that it is the botanists who have suggested its possible animal nature, the zoologists inclining to regard it as a plant.

Having collected and long studied the specimens, superintended their delineation, and compared them with a great number of forms both fossil and living, I may be permitted to advance in as few words as possible, the

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theory which I provisionally hold as to the nature of this organism, as follows: I am disposed to regard it as a "comprehensive type" of vascular cryptogamic life, embodying some of the characters of several well known living types, viz., 1. The large tufted central base is suggestive of that of most species of Isoetes, and the long weak stems of certain of these species are observed to recline and lie prostrate in all directions around this center. 2. The double row of spore-cases at the apex of the stem agrees in all essential respects with that of Ophioglossum, and the elliptic expansion may be regarded as homologues of the larger blade-like fronds of that genus, which may easily be imagined to have the spores borne along its median line instead of on a special fruiting frond. 3. The prostrate sinuous habit is not widely unlike that of certain creeping species of Lycopodium, as, e. g., *L. annotinum*, and the toothlike appendages may be the reduced homologues of the scale-like leaves of that genus. 4. A still further approach is seen in Selaginella where the scales have become distichous and the stems flat and closely creeping. This parallel is well-nigh complete in those species, such as *S. Douglasii*, in which the spores are borne in terminal spikes, like those of most Lycopodiums, except that these are more or less flattened and two-ranked. 5. Finally, ignoring the appendicular organs of Marsilia we see in the fruit-bearing portion a further analogy to our fossil, the fruiting stems radiating from the thickened base and bearing the spores at their apex.[1]

The fossil would thus represent a highly generalized type and may be phylogenetically related to all these more specialized modern forms with each of which it seems to possess some characters in common.

The paper was illustrated by lantern views of the original fossils and of carefully prepared drawings.

THE PALEONTOLOGIC HISTORY OF THE GENUS PLATANUS.[2] By Prof. LESTER F. WARD, U. S. Geological Survey, Washington, D. C.

[ABSTRACT.]

THE genus Platanus is one of those waning types, like Ginkgo, Sequoia, Liriodendron, etc., of which so much has been said of late, and though now constituting an entire order and containing only seven species, it is evidently the descendant of a large family embracing a number of genera, each with a fair representation of specific forms. Twenty extinct species of Platanus are now recorded from Tertiary and Cretaceous strata, which are, however, in most cases founded on the impressions of leaves. But in

[1] Since the date at which this paper was read communications have been received from the Marquis Saporta and from Dr. A. G. Nathorst, both of whom agree that the organism is probably a cryptogamic plant related to Ophioglossum.

[2] Published in full in the Proceedings of the United States National Museum, Washington, 1888, Vol. XI, pp. 39–42, pls. XVII–XXII.

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addition to these there is a large number of aberrant types resembling Platanus in many respects, though also resembling some other living genera, which have been variously referred to Sassafras, Aralia, Liquidambar, Liriodendron and to the supposed extinct genera Araliopsis, Aspidiophyllum, Protophyllum and Credneria.

The object of this paper was to point out the probable genetic relationship among all these extinct types and to show that they are the probable ancestors of the modern genus Platanus. Special emphasis was laid upon the significance of the basilar lobes of the form described by the author as *Platanus basilobata* from the Fort Union group, and upon the connection between this and similar appendages sometimes found on leaves of *P. occidentalis*, and of certain fossil species of Platanus, Aralia, and Aspidiophyllum. The supposed Sassafras leaves of the Dakota group were also discussed with a view to showing that they are also archaic platanoid types, and it was argued that the nervation of these leaves differs in some fundamental respects from that of the leaves of the only living species of that genus, the normal form of which was shown to be entire and not trilobate, as is commonly supposed.

Finally, it was contended that, inasmuch as five of the seven living and a large preponderance of the fossil species of Platanus, as well as most of the ancestral forms referred to, are American, and as the type is found in this country in very much older strata than in the Old World, it must be conceded that, notwithstanding the historic antiquity of the oriental plane tree in connection with the early development of the human race in Asia and Europe, nevertheless it is, paleontologically, an American tree, and had its origin in this country.

This paper was illustrated by lantern views of fifteen of the forms selected to exhibit the phylogenetic development of the genus.

EVIDENCE THAT LAKE CHEYENNE CONTINUED TILL THE ICE AGE. By Prof. J. E. TODD, Tabor, Iowa.

[ABSTRACT.]

THIS paper called attention to several facts hitherto unpublished which indicate that eastern Nebraska, western Iowa and southeast Dakota were occupied by a fresh water lake when the drift first began to be deposited in that region. The facts and considerations are as follows:

1. An extensive deposit of fine sand containing a few fossil bones, overlain in some places by a lead-colored clay without pebbles, and some fossiliferous silt resembling loess, is found occupying much of the region, especially at lower levels. Ten localities were mentioned where these formations have been observed, the more notable being Fairview, Dak., Mills Co., Iowa, and Lancaster Co., Neb. A large fossil claw of some gigantic

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mammal[1] was shown which was obtained from Mills Co., Iowa, in the sand below the drift.

2. The occurrence of a stratum of volcanic ashes in such position as to show that wide areas were occupied by still water, just preceding the deposition of the drifts in some parts and during it in others. The localities described and pictured were in Knox Co., Neb., and near West Point, Neb.

3. An objection which may be urged, from the depth of the channel of the Missouri in this region, is removed by several facts which go to show that said channel has been wholly excavated since the glacial epoch.

(*a*) The rock under the present bed is unglaciated and unoccupied by drift deposits, as has been recently demonstrated by observations made in sinking the piers of bridges at Blair and Omaha.

(*b*) The Missouri is still deepening its trough with every great flood. This has been determined by soundings at such times.

This fresh water lake, from its time and location, may be quite confidently considered a portion of the great body of water which occupied the western plains during late Tertiary times, and which was named by King, Lake Cheyenne.

THE TERRACES OF THE MISSOURI. By Prof. J. E. TODD, Tabor, Iowa.

[ABSTRACT.]

THIS paper embodies the observations of the writer while connected with the U. S. Geol. Survey, during the last six years. They extend from the 41° to the 46° of latitude.

The terraces are found to be readily arranged in three groups, viz.: The Silt Terraces, which rise from 5 to 175 feet above the present stream, the Lower Bouldery terraces, from 70 to 350 feet, both these being much higher toward the north, and the Higher Bouldery Terrace, which has been less definitely and extensively traced, rising from 350 to 475 feet. The development, location and structure of the different terraces were discussed in detail.

All decline in height down stream. All contain coarse material, boulders and gravel, but this is especially prominent in the bouldery terraces, and in all this diminishes in amount down stream. Even the bouldery terraces are commonly capped with silt several feet in depth.

The lower silt terraces were not considered; the highest one of this class was observed at Pierre to be 160–125 feet above the river; near Crow Creek Agency, 150–110; at Chamberlain, 125; ten miles above Wheeler, 85; Wheeler, 105–85; Fort Randall, 80–45; and at Niabrara, about 25 feet above the river.

[1] Since the above was written this has been determined by Professor Leidy to be a claw of *Megalonyx*.

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The lower bouldery terraces, two of which may be traced above Whe
er, are by far the most distinctly marked and extensively developed. T
upper one shades, on the one hand, into the adjacent upland and, on t
other, gradually subsides into the lower terrace of this group. This
especially seen above the Bijou Hills at Le Beau and about Chamberla
The upper seems to mark about the surface of the former stream, wh
the lower sometimes corresponds to the bottom of ancient channels, o
of the more remarkable of these, for example, extending southwest fr
American Crow Creek past Red Lake to the Missouri.

From the vicinity of the mouth of Pratt Creek, both terraces rapi
decline down stream to a lower level which is reached near Yankt
Agency, where they seem to coalesce and from that point they are ind
tinguishable. This is attended with a widening of the terrace betwe
Yankton Agency and Choteau Creek, to a breadth of three or four mil

The following table sufficiently shows these facts.

Heights on the lower bouldery terraces above the river.

LOCATION.	LOWER.	HIGHER.
La Grace	240–250	
Le Beau	200	300
Mouth of Little Cheyenne		250–270
Pierre		275–325
Crow Creek Agency	200–250	320
Two miles above Chamberlain		325
Five miles below Chamberlain	200	300
Little above Bijou Hills	100–175	
Near mouth of Snake Creek	150	330
Near mouth of Pratt Creek	90–126	300–350
Ten miles above Wheeler		200–250
Wheeler		135–175
Yankton Agency	180–240	
Niobrara	200	
Yankton	120–145	
Sioux City	115–150	
Blair	90–110	
Bellevue	50–70	

Traces of this terrace, more or less conspicuous, are found on most,
not all tributaries of the Missouri outside of the Second or Gary Morain
It has been specially noted, by the writer, along White, Niobrara, Jame
Big Sioux, Elkhorn, Little Sioux, Boyer and Platte rivers. One-half t
three-fourths the height of this terrace is usually composed of old
rocks, and the upper portion of drift, sometimes stratified, but often ver
closely resembling till, with 10–15 feet of silt usually capping the whol
Boulders are often abundant, especially in the vicinity of the moraine, an
where the terrace slopes rapidly, as near the mouth of Pratt Creek.

The higher bouldery terraces are least perfectly developed. Their ag

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height above the river, and the probable lacustrine character of much of the river at the time of their formation accounts for this.

There seems to have been but one, except near the Bijou Hills. Its height above the river does not vary greatly from 400 feet; and at the mouth of the Niobrara seems to become continuous with the upper or western limit of the drift in Nebraska.

A comprehensive view of the data given leads to the following conclusions:

1. The southward sloping of the terraces does not demand, though it would favor the idea that there had been recent northward elevation.

2. The abrupt descent of the lower bouldery terraces below the Bijou Hills indicates that the Missouri has recently cut through the divide between the White and Niobrara rivers, as was suggested by the writer in 1884 (See Proc. A A. A. S., 1884).

3. Because the lower bouldery terrace extends up the James river, Pratt Creek, Okobojo, Little Cheyenne, etc., through the first moraine to the gaps of the second moraine, it is correlated in time with the occupation of the second or Gary moraine, while less confidently the higher bouldery terrace is similarly correlated with the first or Altamont moraine.

SYSTEMATIC RESULTS OF A FIELD STUDY OF THE ARCHÆAN ROCKS OF THE NORTHWEST. By Prof. ALEXANDER WINCHELL, Ann Arbor, Mich.

[ABSTRACT.]

Two entire seasons spent by the writer in the study of the Archæan rocks of Minnesota, Wisconsin, Michigan and Canada, in addition to more casual studies during many years previously, have resulted in a view which seems clear, simple and conclusive, respecting the grand divisions existing, and their equivalences at remote points. In the typical Huronian region of Canada, we find two massive quartzite terranes underlain by blackish, siliceous argillites—the "slate conglomerate" of Logan and, at bottom, another and more vitreous quartzite. Intersecting these are vast dikes of diabases, often slaty and in some places of such extent as to appear interbedded sheets. The "Animike" formation of Thunder Bay and of northeastern Minnesota is continuous with the siliceous argillites, and lithologically identical, but with accessions of flinty and jaspery beds, and especially in Minnesota of vast deposits of magnetitic schist. Underneath this system, and in marked discordance of stratification with it, is a system of argillitic sericitic and chloritic slates, which embrace the hæmatites of the Marquette, Gogebic and Vermilion regions. Unquestionably this system is not Huronian, though generally so reputed. Still lower, but stratigraphically comformable, occur crystalline schists, followed by vast beds of gneisses. The crystalline schists ally themselves

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with the gneisses and graduate into them. All these present the characters ascribed to the Laurentian. But it must be said that true unbedded granites are seldom if ever seen within the range of my observations. We have then the three following systems of Archæan rocks:

III. A system equivalent to Huronian.

II. A system unnamed (Marquettian.)

I. A system equivalent to Laurentian.

THE USE OF FOSSILS IN DETERMINING THE AGE OF GEOLOGIC TERRANES. By Prof. H. S. WILLIAMS, Ithaca, N. Y.

[ABSTRACT.]

THE study of the data and the methods employed in comparing the Russian Devonian (as described in a paper by P. N. Veunkoff) with the Devonian of the Eifel and Ardenne regions of northern Europe (as discussed by M. Achile Six in a paper "on the Russian Devonian" in Annales de la Société geologique du Nord, XIV, p. 67-126, 1887) and these with the Devonian system in America, gives me the occasion to formulate and discuss the following proposition:

Whenever the attempt is made to determine the relative geologic age of separate terranes the following rules are believed to be generally applicable.

1. It is not the more conspicuous and fixed characters of fossil species which furnish the most valuable data for determining age, but the slight and generally more or less plastic characters.

2. It is the degree of prevalence and abundance, and not the mere presence or absence of a particular temporal modification of a species that constitutes the most reliable indication of the age of a terrane.

3. Faunas taken as wholes are more valuable than individual species—and the fauna thus considered includes the elements of *relative abundance* of the component species, and takes account of the relation which the *epochal facies* of each species bears to its typical form, and the *temporal place* the species occupies in the history of its genus.

THE FOSSIL WOOD AND LIGNITES OF THE POTOMAC FORMATION. By F. H. KNOWLTON, U. S. National Museum, Washington, D. C.

[ABSTRACT.]

PERHAPS no American geological formation, which has been made the subject of recent investigation, has given rise to more extensive discussion

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or has furnished more valuable scientific results, than has the Potomac Formation. First clearly differentiated by Prof. Wm. B. Rogers, as long ago as 1840, it has during the past decade, and more particularly during the last three years, been made a special study by Messrs. McGee, Fontaine, Ward and Marsh, and at the present time the history of its deposition and abundant animal and plant life, is better known than is the history of many of the European formations with which it has usually been correlated. Its exact stratigraphic position, however, is still unsettled, although strong presumptive evidence is at hand. It was called by Rogers, the Jurassocretaceous or upper secondary sandstone. In 1885, Mr. W. J. McGee, arguing from the then available paleo-botanical evidence, considered it to be "Lower Cretaceous in age—the American equivalent of the European Neocomian." Prof. Wm. M. Fontaine, who has so thoroughly worked up the plant impressions, regards it as Wealden, while Prof. O. C. Marsh, who has studied the numerous vertebrate remains, claims for it a Jurassic age.

The Potomac Formation is remarkable for containing the oldest dicotyledonous flora yet discovered. Of the three hundred and sixty-five species of plants described by Professor Fontaine, no less than seventy-five species are dicotyledons. They do not consist of the highly differentiated genera and species which characterize the other dicotyledonous floras, such as the Dakota group, but are new and strangely archaic in appearance.

My own studies of the Potomac Flora have been extensively confined to an investigation of the internal structure of the fossil wood, which is very abundant in this formation. It occurs under two widely different conditions, viz.: as lignite and as silicified wood. Both these forms, as indeed all the plant remains, occur principally in lenticular pockets of hard, bluish clay, which pockets bear evidence of having been transported *en masse* from the original beds in which they were laid down. There is almost no transition between the two forms, although there is evidence that some of the silicified forms are also represented in a lignitized state; that is owing to different conditions of fossilization, some specimens of a species were silicified, while others were turned to lignite.

In color the lignite is almost uniformly jet black. It has a specific gravity of about 1.333, and breaks with a true conchoidal fracture like ordinary anthracite. When thus broken, it does not exhibit superficially the slightest trace of organic structure. It may, however, be split along certain lines, notably in the direction of the medullary rays, when very plain structure shows superficially. The method of examining this lignite, was that recommended by Griffith and Henfrey in their Micrographic Dictionary (2d edition, p. 178), for the examination of coal. When prepared this way, the sections are tolerably transparent, and the structure is easily made out. The most casual examination shows that this material has been subjected to great pressure, which has so entirely crushed and distorted the cellular elements, that it is difficult to recognize the original form. The examination of a large series of sections serves to give a pretty correct general idea of it. In transverse section, the lumen of the cells is seen to be almost entirely closed up, the result of lateral pressure.

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In regard to the identification of this lignite, it is manifestly impossible to attempt more than an indication of its general character and position. That it is coniferous, is beyond question. The absence of wood elements other than tracheïds, which were provided in some cases at least, with bordered pits, and the number and arrangement of the medullary rays, make the coniferous nature clear. From the abundance of the genus Cupressinoxylon, in the Potomac Formation, as shown by the silicified examples, it is probable that most of the lignite may be also of this genus, particularly as there is in many cases, a marked resemblance, so far as I am able to interpret the distorted structure, between it and some of the species described from silicified specimens. Also several species undoubtedly entered into the composition of this lignite.

The silicified material was examined by the methods usually employed in the study of petrographic material, viz.: by cutting thin sections and mounting in Canada balsam. This material is all coniferous. It belongs to two well-known genera, Cupressinoxylon and Araucarioxylon.

Cupressinoxylon, as now accepted, is a somewhat comprehensive genus and is usually regarded as representing in a fossil state, the wood of Sequoia, or a nearly allied form. This view is strikingly confirmed in the present instance, as Professor Fontaine has described, from cone and leaf impressions, no less than twelve species of Sequoia, and typical cones of Sequoia have been found at Beltsville, Md., associated with the lignite and silicified wood. Four species of Cupressinoxylon have been detected from the Potomac Formation, and although possessing affinities with the other described forms, they nevertheless differ from them in important features, and have all been regarded as new to science. They have been named as follows: *C. pulchellum*, *C. McGeei*, *C. Wardi*, and *C. Columbianum*.

The genus Araucarioxylon represents the wood of the Araucarian pines in a fossil state. The single species is described as new under the name of *Araucarioxylon Virginianum*.

THE GLACIAL BOUNDARY IN SOUTHEASTERN DAKOTA. By Prof. G. FREDERICK WRIGHT, Oberlin, Ohio.

[ABSTRACT.]

THE object of this paper was to present the result of some observations made during June and July of the present season in the vicinity of the Missouri river between Yankton and Fort Yates in Dakota. The country traversed is in part that reported upon by Professor J. E. Todd at the Philadelphia meeting of this association in 1884 (see Proc., pp. 381–393).

After giving a summary of the facts relating to the character of the glacial deposits near the boundary of ice action in the eastern and central states, the speaker proceeded to say: The surprising thing to a glacialist

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upon a first visit to southeastern Dakota is the extent of the apparently level area where the till comes to the surface. This impression is heightened probably by the absence of forests, and would very likely be the same in portions of Ohio and Indiana were it not for the timber. James river valley in Dakota is depressed in the centre about five hundred feet below the edge, but it is, roughly speaking, seventy miles across; so that the slope does not strike the eye. So level is the country that every special line of glacial accumulation is a prominent feature in the landscape, and the various halting-places of the ice in its retreat are readily discerned, and were accurately delineated, so far as my observations have extended, by Professor Todd in the paper referred to. For a long time a lobe of ice filled the James river valley, running parallel with that occupying the upper Minnesota valley, and extending southward into Iowa. The edges of these lobes thinned out along the north and south line which runs near the east margin of southern Dakota, and favored the accumulation of the lines of hills known as the "Coteau des Prairies." Professor Todd and others speak of this as a series of "terminal moraines" formed along the sides of the reëntrant angle whose apex penetrated to the vicinity of the Sisseton Agency. I am not sure but that it would facilitate an understanding of the subject to speak of the Coteau des Prairies as a *medial* moraine toward which the glacial debris (carried upon the deeper portions of the ice) gravitated in both directions. But certain it is, that, starting from a point at the Sisseton Agency different lines of glacial accumulations stretch southward at varying angles,—the later accumulations forming the more obtuse angle. Coming up the valley of the James from Yankton one crosses the oldest of these accumulations (the Altamont moraine) in the neighborhood of the city itself, and the second (or Gary moraine) in the neighborhood of Mitchell, sixty miles to the north, having run parallel with it, however, for about thirty miles. The third, or Antelope moraine, is encountered near Huron, about sixty miles north of Mitchell, and continues visible upon either side of the river, about twenty miles distant, beyond Aberdeen.

On the western side of this lobe there are corresponding lines of accumulation, the outer of which is the vicinity of the Missouri river and on its eastern side. Everywhere in coming up from the Missouri on to the plateau, which is in most places from four hundred to five hundred feet above the river, one encounters two or three terraces covered with boulders, the two highest of which are about three hundred and four hundred feet respectively. These moraines rise out from this general level one hundred or two hundred feet higher, and are marked features of the landscape. The streams entering the Missouri from the east are all of them short, the longest not being more than forty miles in length. These streams are in all cases that I observed marked by broad and elevated local terraces, the edges of which where they overlook the immediate trough of the stream are crowded with granitic boulders. In some cases, as Professor Todd has shown, these valleys terminate abruptly at the water-parting, as if being the continuation of glacial streams from the east which had originated upon the ice lobe while it filled the James valley. The boulders

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which are superabundant over all this region are largely of granite o gneiss, and must have been transported over a long distance, in some cas probably more than four hundred miles, from the northeast.

Owing to the difficulty of penetrating the Indian reservation, Profess Todd had not been able to extend his observations to any great exte west of the river and north of Pierre. But through the courtesy of Re Thomas L. Riggs, and of his assistant, Rev. James F. Cross, missionari to the Sioux, I was permitted to enter the reservation at Fort Yates, a traverse with them, on the west side of the river, the region intervenin between Fort Yates and Oahe, in the vicinity of Pierre, making the di tance travelled over about 150 miles.[1] Leaving Fort Yates, and going fo miles in a south-southwesterly direction, we reached an elevation of 4 feet, all of which was made during the last mile, and represents the gener height of bluffs on either side of the trough of the Missouri, which here about four miles wide. The elevation of Fort Yates above tide 1694 feet, making the elevation of the bluff 2119. The fort is situated o a glacial terrace about fifty feet above the present high-water mark. Eig miles farther on, the elevation was 2294 feet, which is about the gener level for many miles. The elevation of Grand River was 1819 feet. Th divide between the Grand river and the Moreau is almost exactly the sam elevation (namely, 2294 feet) with that between the Grand and Fort Yate South of the Moreau river the divide between that and the Cheyenne ris to 2404 feet. Over the whole of this distance from Fort Yates, boulde of granite and gneiss were very abundant, being as numerous upon t higher as upon the lower points. Frequently the boulders were sever feet in diameter. But, two or three miles to the south of the highest la between the Moreau and the Cheyenne rivers this northern drift sudden ceased at an elevation of 2354 feet, or fifty feet lower than the previo reading. From this point south and east to Oahe (a distance of abo sixty miles) no signs of northern drift were seen, except in the valley the Cheyenne river, upon coming down to a level of 2100 feet. The elev tion of the higher land between the Cheyenne and the Bad river was fro 2200 to 2300 feet. Upon coming again into the valley of the Missou northern drift began to appear immediately upon the western bluff, about 2100 feet above tide.

The western limit of drift upon the Northern Pacific railroad is fixed Professor Chamberlin at Sim's Station, about forty miles west of Bi marck. Prof. N. H. Winchell, in his report upon the Custer expediti to the Black Hills, in the summer of 1874 (see pp. 22 and 23) found t limit of drift to be in the Dog Teeth Buttes, thirty or forty miles south Sim's Station, and about twenty miles west of the 101st meridian. Pu ting these observations with my own, it would appear that the limit

[1] As I had no barometer with me, the elevations given were determined by Rev. M Riggs upon a subsequent journey, and forwarded to me. Being the result of sing readings, they are of course liable to a considerable margin of error, which, howeve may be eliminated in subsequent journeys. But I am confident that the margin error is not large, since the readings are nearly correct at the river crossings.

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glacial drift between the Northern Pacific railroad and Pierre runs from Sim's Station southward, crossing in a pretty direct line the valleys of the Cannonball, the Grand, and the Moreau river, to the divide between the Moreau and the Cheyenne, where it is certainly ten or twelve miles west of the 101st meridian. At this point it is running nearly east and west between the Moreau and the Cheyenne; but just where it strikes the trough of the Missouri I am at present unable to tell. It certainly cannot be much west of the mouth of the Cheyenne.

Over the glaciated portions traversed, I was unable to find any typical deposits of till, but this may have been owing to the absence of favorable places for observation, since the rolling prairie region afforded few opportunities for erosion. Frequently, however, knolls and short ridges projected above the general level, and were literally covered with boulders, pebbles, and gravel, all of which appeared to be more or less washed. Nor was I able to find on any of the boulders distinct marks of glacial scratching. About halfway between the Grand and Moreau rivers, upon the very summit, we traversed an extensive shallow depression resembling a kettle-hole about two miles wide. This was bordered by hills about one hundred feet above the bottom. The rim was marked by numerous knobs which were perfectly covered with granitic and gneissoid boulders. Many large boulders were also scattered over the bottom, these being frequently from three to four feet in diameter. The boulders seem to be limited to a superficial deposit. On approaching the Moreau, while still upon the high land, numerous boulders from four to eight feet in diameter were observed.

On striking into the valley of the Cheyenne river, about twelve miles above its mouth, and coming down upon a terrace, about three hundred feet below the general level, a few small gneissoid boulders appeared. Again on crossing the river at about the same elevation, we struck into an old river-bed, which seemed to be perfectly level, and about two miles wide, and to extend as far as the eye could reach both up and down the valley. Granitic pebbles were abundant in this deposit and they were all well waterworn, and evidently occupied a depth of a number of feet. Here and there over it were scattered a number of small granitic or gneissoid boulders a foot or more in diameter. Whether the source of this granitic material was the glaciated region to the north or not, I am at present unable to tell, since the Cheyenne has access to granite in the Black Hills where it rises. Still, from the similarity of the boulders to those found on the highlands to the north, I think a connection will be found between this old river-bed and the glaciated region to the north. I am inclined to believe that this is the line of marginal drainage by which the water (which both before and since occupied the trough of the Missouri) worked around in front of the ice, meeting the Missouri valley near the mouth of the Cheyenne river. Since my return, Mr. Riggs has crossed the Cheyenne about six miles farther up stream, and reports this old river-bed as there on the north side, and coming in from the north at an angle of about twenty degrees. I shall look for further evidence of this stream having worked around Fox Ridge from the glaciated region where we left it on the divide between the Moreau and the Cheyenne rivers.

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About ten miles south of Grand river, however, we found Long Butte t be not like the buttes which had occurred at frequent intervals in previou parts of the journey, capped with sandstone, but to be a gravel deposit ev dently an old river bottom containing much material brought down fro the Black Hills, and all well waterworn. This ridge extended for some mile being a very marked feature in the landscape, and is, I suppose, a remna left by the erosive forces which had operated for a long time upon th underlying cretaceous formations, wearing them away faster than they di the superincumbent gravel deposit.

The further study of this portion of the glacial border, will be importa for its bearing upon current theories concerning the glacial period. Th thinness of the deposit, and the washed appearance of the material which it is composed, will be interpreted by some to indicate that it the eroded and wasted margin of a first glacial period, separated by a enormous lapse of time from the last glacial period. This, however, doe not seem to me to be necessarily the case. In interpreting the marginal de posits of the glacial period, we should remember that the motion of glacier constantly diminishes towards the margin until it finally reaches line of stability; so that the deposits at the very margin are those whic have been carried upon the ice, rather than shoved along under it, whic would account for comparative absence of abrasion. Furthermore, the ma ginal deposits are, of course, the older deposits on any theory, and hav been longest subjected to the action of erosive and disintegrating agencies Thirdly, in the present case, these marginal deposits were peculiarly sub ject to erosive action from the vast drainage of the Missouri river whic had been pushed out of its natural channel. These considerations seem to me still to leave it an open question, so far as these deposits are con cerned, whether they do not belong to an earlier stage of the same epoc during which the heavier deposits had been made upon the east side of th river. At any rate, it would seem that the abruptness of the terminatio of these deposits, shows that they were due to direct glacial action, rathe than to that of floating ice. It would be difficult to conceive of a subsidenc in that region which should have produced a body of water with a shore co responding to this drift limit. Now that the country is likely soon to b opened to settlement, we shall look to investigations in that quarter fo much light upon many problems of glacial theory.

SOME THOUGHTS ON ERUPTIVE ROCKS WITH SPECIAL REFERENCE TO THOS OF MINNESOTA. By Prof. N. H. WINCHELL, State Geologist of Min nesota, Minneapolis, Minn.

GEOLOGISTS know of but two sources for all the rocks which constitut the crust of the earth, viz.: (1) cooling from fusion, and (2) solidifyin after being disintegrated and distributed by water. Under accepted hy pothesis the former were first to be formed, and the latter have resulted b a long continued series of dissolution and selection through the agency o oceanic water, from the former.

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Those that have cooled from fusion, known as igneous, or eruptive, rocks have been divided broadly into *basic* and *acid* eruptives. Though it is obvious that this distinction may fade out when subjected to universal and rigorous application, yet for the purpose of this paper it may be accepted in advance, since these terms do afford a classification which covers a multitude of facts and sufficiently characterize the two evident great divisions of eruptives.

In offering to the Section a few thoughts on these two classes of eruptives I wish to disclaim any desire to ignore the views and facts that have been published by others. I shall simply base some statements on some facts which have come under my own observation, to which I have given considerable reflection during the past ten years, derived from my work on the geological survey of Minnesota, referring to my reports for details of the evidence. Time has not yet been given to make an exhaustive study of similar facts from other parts of the world, and the tentative hypotheses that I shall give may have to be modified or abandoned on making wider comparisons.

The *basic eruptives* are sometimes distinguished as *volcanic*, in distinction from the acid which at the same time have have been called plutonic. They are such as are known commonly to have flowed in recent times from volcanic vents, and to have been spread in extensive sheets and streams over the face of the earth. They are heavy, dark-colored, often bearing iron-peroxide (and in rare cases metallic iron): as a group they are dolerytes,[1] and embrace diabase, basalt, some of the diorytes, and those rocks that in Wisconsin and Minnesota have been designated gabbro. They contain less than sixty per cent of silica.

The *acid eruptives* (so called) are such as have been supposed to have constituted the earliest super-crust of the earth, and are now exposed at the surface because they have been kept uncovered by denudation. They occupy, where seen on the continental areas, the lowest of the rock strata; and from these ancient bosses are seen various offshoots that penetrate in forms of veins, sheets and dikes, the rocks immediately overlying. In the higher rock horizons this class of eruptives is comparatively rare, but isolated small areas are known in Europe and America. In most instances, however, in which they are found in Silurian, Carboniferous or Tertiary time, they seem to exhibit a diversity of minor characters of structure, by which they are distinguishable, though their chemical composition, in its essential ingredient of silica, shows their general alliance to this class of eruptives. The acid crystalline rocks embrace granite, syenite, apparently some diorytes, felsyte, trachyte, quartz-porphyry and all such as have a silica content of sixty per cent or more.

In addition to the distinction of content of silica these two classes exhibit other differences, when compared in their original and unweathered state, and when not modified by immediate contact with other rocks. The basic rocks are *dark colored*, gray, varying to hornblendic-brown or chloritic-green. The acidic as a class are of *lighter colors*, as required by the

[1] Dana: *Am. Jour. Sci.*, Nov., 1878.

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higher per cent of silica, red, pink, gray, olive-gray, bluish-gray and grayish-white. They are often porphyritic with quartz and with orthoclase. They differ also in weight, the basic rocks having specific gravity from 2.65 to 3.5, and the acidic from 2.4 to 2.7. In general the specific gravity of the basic may be stated at 3, and of the acid at 2½.

One of the most noticeable differences, however, between the basic and the acid rocks, is in their *manner of occurrence and their relative amounts, among the other strata.* The basic eruptives have poured out from the interior of the earth in vast floods, covering the surface for thousands of square miles. When solidified they present a homogeneity of character and composition that demonstrates the vastness of the source from which they came, such as can be explained only by referring it to the molten, original interior of the earth. All the attendant phenomena of fissures filled by molten rock, profound heating and changing of the preëxisting strata, and the basaltiform structures that result from slow cooling, attend these wonderful eruptive sheets. On the other hand, the acid eruptives, when they possess the undoubted characteristics of a former fluidity—*i. e.* if they fill fissures in rocks that preëxisted, and are separated from the basal (Laurentian) gneisses—are found to be of small amount and scattered very arbitrarily and haphazard among the other strata. They are not known (in Minnesota) to have been spread out in sheets like the basic dolerytes, although some of the felsytes are in sheets that are embraced in the stratification of the terrane with which they are associated. They rise in isolated knobs, here and there, unconformably overlain by later sedimentary strata, or they pass by slow changes, when traceable, into crystalline masses that appear to belong to the Laurentian gneisses. In the territories the trachytes form isolated buttes that are thrust upward in the Tertiary and Cretaceous strata. They exist as laccolites rather than overflow sheets.[1]

The two classes of eruptives are *differently distributed in time and rock horizon.* The acid rocks form the fundamental gneisses of the Laurentian, constituting rock masses many thousands of feet in thickness. Subsequent to that time they dwindle in amount, and exhibit a diversified character, but break out again with considerable abundance in Tertiary time. The basic eruptives appertaining to the age of the Laurentian gneiss are so rare that they may be considered wanting, or at least at the present time undiscovered. They appear in the later crystalline terranes, and they seem to have increased in amount in Silurian time, to have prevailed widely in Mesozoic time, and to have culminated in the Post Tertiary.

If we seek for *similarities* between these two classes, we find that they both show evidence of former plasticity, have been mechanically transposed from one position to another among the rocky strata, have each produced a metamorphic effect on the contiguous rocks, have cooled and congealed, taking a more or less perfectly crystalline texture, and by entering the fissures have recemented the strata when they have been rent by upheaval, thus constituting dikes and elvans.

[1] G. K. Gilbert: The Geology of the Henry Mountains, 1877.

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These contrasts indicate different sources, or methods of generation, and it is the purpose of this paper to call attention to a plausible hypothesis which assigns to each a genesis which is consistent with a great number of facts.

The basic eruptive is of *unquestioned deep-seated origin*. It has flowed from the interior of the earth at great epochal intervals, and is known to flow from volcanoes at the present time. But throughout its history it has maintained a constancy of character. The dolerytes of the Post-Tertiary are not distinguishable from those of the Cretaceous and Jura-Trias, nor from those of the Cambrian. The diabase of the Taconic, when fresh, is not different from some of the finer dolerytes of the Tertiary. The so-called gabbro of the Mesabi, in Minnesota, is found to graduate into a rock which is diabasic. The peridotytes of the Kawasachong eruptive are also diabasic. An earlier probably eruptive rock (the Vermilion outflow,—the mica-hornblende rocks which I have styled the *Vermilion group*) while evidently changed from its original condition, yet exhibits the essential elements of a basic eruptive, and in some places becomes a basic dioryte.

It being admitted that the basic eruptive has risen from a deep source through the fissures that have been formed in the crust of the earth, it remains to find a reasonable explanation for the occurrence of acid eruptive rock.

It is difficult to understand how from the same volcanic vent shall flow, from the same source, successive floods of basic and acid rock. In those few instances in which such a phenomenon has been asserted it may safely be affirmed, still, that the acid rock is not known to have come from the same depth as the basic, and hence it is allowable to suppose that it came from a less depth. This being granted, there is no fact known to the writer which conflicts with the following general principle, which I shall take as the *theme* to be discussed.

All acid eruptive rocks result from the hydro-thermal fusion of preëxisting sedimentary strata embraced in the super-crust of the earth.

(1) The "fundamental gneiss" which in America is admitted to be the *Laurentian gneiss*, has been supposed to have constituted the original crust of the earth, which resulted from the congelation of the surface of the globe. But *a priori* it seems that this is highly improbable, if not impossible, from all that we know of the nature of that molten mass. This gneiss is an acid rock. The molten rock that above is admitted to have come from below the crust of the earth is basic. If the nature of the rock which formed the first film of rigid matter over the primeval earth be called to mind, we have no authority for making it an acid film. *It was a basic film of dark pitchstone.* It was formed, shattered and reformed. It was broken and washed by the mists and waves of the infant ocean. It was dissolved by the hungry fresh waters of the perennial rains. It was buried under its own ruins. As it became able, in scattered small spots, to constitute rigid land, it was washed by the ocean and again dissolved. About its shores accumulated siliceous beaches. About these beaches, as they emerged, other

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beaches were formed. Then, by some disturbance, they were all buried. Then they slowly emerged again, and the land grew by further sandy accretions. The ocean's waters seized all the soluble ingredients, and the soluble ingredients were more numerous, since the waters were hot, than they are at the ocean level at the present day. The insoluble were left on the shores. The land grew through the Laurentian age, with vicissitudes of upheaval, solution, submergence; and emergence, solution and siliceous accumulation. The continents were in embryonic condition, but they were *necessarily of acid rock.* Locally, and perhaps sometimes generally, this siliceous sedimentation was invaded by overflow of basic eruptions from below the crust. But as the crust was thin, the stress would be slight, and the fractures were of small moment, giving rise to but inconsiderable outflows. They seem to have been lost, during the Laurentian age, either by resolution by the ocean and the distribution of the insoluble residue along the shores, or by later hydro-thermal metamorphism. As the sediments increased in thickness, the alkalies and alkaline earths were steadily abstracted by the powerful solvent and destructive action of the ocean. This process once begun, would result, if continued through geological time, *in the formation of acid continental areas.* But as the ocean became more and more alkaline it necessarily reached the point of saturation, and began to make rocks, off shore, of another sort, producing limestones and magnesian limestones, and to furnish conditions fit for the display of low animal life. The palæozoic limestones resulted. Further additions to the continental areas brought these limestones, and all later rocks, to the level of the dry land, while at the same time burying under deeper and deeper loads of superincumbent rock material, the sediments of the Laurentian ocean.

(2) The sediments of the Laurentian age, therefore, being necessarily siliceous, when acted on by the well-known forces of heat and pressure undergo the consolidation and crystallization which is attributed to these agents. *They constitute the acid "fundamental gneiss."* They are not only consolidated, but within the broad expanses of the later continental history they are subjected to that hydro-thermal re-fusion which is now admitted to pervade not only the original igneous matter of the earth's crust but also the strata of the super-crust. In this plastic condition they are ready to enter all the avenues that open for the escape or release of plastic matter under pressure; and they have made their appearance at many places and at all times in the geological history of the earth. The variability of these acid eruptives in composition, color, and degree of crystalline structure, together with the smallness of their geographic area, and comparatively limited amounts, go to indicate not only a variable source but a comparatively limited supply. As contrasted with the constancy of composition and vast floods that characterize the basic, this is one of the me[illegible] important differences.

[illegible] *of eruption of the acid rock is frequently, if not generally, [illegible]lites, instead of surface overflows.* Considering the greater [illegible] the basic eruptive, it has been remarked by Mr. G. K.

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Gilbert that it is a remarkable fact that in the territories of the United States, the basic eruptive has, so far as known, always been ejected at the surface, while the lighter acid, so far as known, has never, or rarely been so ejected in any considerable amount, but has insinuated itself laterally, within the strata of the superincumbent rocks, before reaching the surface, forming the *laccolite*, which Mr. Gilbert was the first to describe (*Geology of the Henry mountains*). To what extent this manner of eruption may characterize the acid eruptive bosses of the Cupriferous and of the Taconic, is unknown; but many of the facts that are connected with these earlier acid bosses in Minnesota, are indicative of such an origin. Now this singular fact, that the lighter eruptives have been able to rend apart the strata through which they were rising on their way to the surface and insinuate themselves horizontally among them, and that the heavier have found rest only by ascending to the surface, is one of those that point most unmistakably to the correctness of the principle above stated.

In the light of late theoretical considerations, the deep-seated strata of the super-crust of the earth, are in a state of hydro-thermal fusion. This condition of fusion is one that allows a more or less complete re-arrangement of the chemical and mineral constituents, although it does not necessitate any profound and wide-spread transposition of those elements from place to place. This condition of plasticity becomes one of fluidity on the removal of the superincumbent pressure. The depth at which this plasticity exists varies with the pressure exerted, and with the degree of heat.

This condition of the super-crust being admitted it needs only to be united with the before-mentioned acid nature of the super-crust, increasing in acidity towards the surface, to bring the plastic mass under those hydrostatic conditions, which are exemplified by the presence of two liquids of different density in the same enclosure. The denser one will seek its equilibrium, and will find its place at the bottom. The lighter one will rise to the level of its equal specific gravity in the surrounding mass. If there be a complication, such as results from the graduation of the lighter into the heavier, through different stages of weight and plasticity, the lighter or more plastic may rise in great blebs through the overlying heavier or less plastic. Such blebs, which may be considered the laccolites of Mr. Gilbert, would rise to that point where they found either sufficient adhesive power in the rocks to resist their further ascent, or an equal specific gravity in the super-crust. There they would rest, after an accumulation of sufficient amount to reëstablish a general equilibrium of pressure.

Mr. Gilbert's statement that such laccolites in the Henry mountains were formed between the sedimentary strata without the creation of fissures in the sedimentary beds, implies, as he argues, that all those beds were under great pressure, and were so affected by hydrothermal forces that they had a semi-plastic condition and were "stretched" to conform with a solid covering, to the fluid intrusion. It would only require that this semi-plastic condition should increase at somewhat greater depth, so as to become a fluid one, with some change in the pressure, or some increase of heat, such as was likely to occur at an epoch of upheaval, to

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institute a bodily transposition of portions of the plastic mass so as t
adjust themselves to the changed relative specific gravity. *Such flow
could never reach the surface.* The plastic condition gives place to a rigi
one before the surface is reached, and, if it did not, the super-crust be
comes, *a priori*, more and more acidic and hence of a lighter specifi
gravity toward the surface. Such intruded masses therefore must occu
only as laccolites.

It may be asked, Why do not the basic eruptives operate in the sam
way, and form laccolites? So far as I can see this can be answered onl
by supposing that they have issued through fissures in the crust of th
earth, that have opened down to the molten interior, and that the duct
through which they have passed have been rigid instead of plastic. It i
obvious, however, that such a vent would first exhaust the plastic aci
layer of sedimentary rock before the basic could obtain access to the ven
Such escape of acid eruptive material would give rise first to a nest o
laccolites, raising the whole surrounding region considerably above th
average level, and subsequently such acid nuclei would form the centra
portions of the mountains or mountain range. If the eruption continue
the ejections at last would become of a basic character, and some suc
seem to have been continued from the earliest geological time to th
present.

Again, it may be asked, How can the eruption of trachitic, or acid, roc
at the surface, be explained, in those instances where it is known at th
present time to form more or less extensive hill ranges? It may b
answered that where such trachitic hills do exist they may be only th
uncovered laccolite of Mr. Gilbert, such as has lately been discovered i
the case of Bear butte, one of the trachitic hills that are found near th
Black Hills in Dakota. The sedimentary rocks of the Tertiary, as well a
of the Cretaceous are rapidly removed by sub-aërial erosion. Hundred
of feet thickness of these strata have been carried away by erosion ove
hundreds, and even thousands of square miles, in western Dakota. Th
present condition of this process of removal is witnessed in the wel
known "bad lands" which occur at various places in the western terr
tories. Such removal over extensive tracts has made old laccolitic in
trusions (as the Bear butte and Inyan Kara) appear as if they had bee
at first sub-aërial extrusions. Again it might be answered that if ac
superficial extrusions have occurred in considerable amount, as seems b
the descriptions of some European geologists, such extrusions were pr
duced by more sudden fracturing and displacement of the whole supe
crust, locally, *by mechanical forces*, so as to allow, or to compel, the u
derlying plastic mass of sedimentary material to flow out at the surfac
of the earth. But it need scarcely be stated that such an occurrence
not governed by the principles that have been appealed to show the ne
essarily laccolitic character of a normal acid eruption. Such acciden
doubtless have occurred and have allowed the extrusion of softer po
tions of the super-crust.

To re-capitulate, then (and there is but one idea in this paper), we fi
the following principle sustained by physical and chemical laws, and n

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at variance with any known geologic facts, viz.: *all acid eruptives are the result of the hydro-thermal fusion of siliceous sediments belonging to the super crust, and all basic eruptives are derived from below the super-crust of the earth.*

If, secondly, we make an attempt to apply this principle to the super-crust and to ascertain what order of sequence there has been in the outflow of basic eruptive material, we shall be able to identify the great epochs of molten, basic eruption by a casual examination of the strata. They have marked characters, and no geologist can mistake them except when they have themselves been subjected, as in the Archæan, to the same hydro-thermal re-fusion and change, or when they have been so modified by atmospheric agents that they are no longer massive but schistose, or have taken silica into their interstices, so that they do not or may not give a basic aggregate percentage of silica.

Guided by these evident characters, I wish to call your attention to the four great epochs of basic eruption which I think are found in the lowest rocks of Minnesota.

(1) *The Vermilion group*, so named in the fifteenth report of the Minnesota survey, embraces what have been styled frequently the *crystalline* schists of that region. They lie next above the Laurentian gneisses. Their manner of contact on the gneiss is remarkable. It is characterized sometimes by several alternations of gneiss with dark crystalline schist, in distinct layers from ten to fifty feet thick, evincing a gradual, or interrupted, transition from one to the other, as if of sedimentary nature. The dark element in these schists is mica or hornblende. At a somewhat higher level in the terrane there is great confusion, and the gneissic rock is mixed confusedly with the schist, in the form of mutually penetrating dikes and isolated patches, which seem to imply a plastic condition for both. But occasionally the dark rock exists in enormously greater quantities and has almost wholly a massive structure. At the same time it becomes almost wholly hornblendic, the micaceous ingredient being visible only on exposed knobs and weathered surfaces; also in the fissures and accompanying the jointage planes. There is unmistakable evidence, which cannot be detailed here, that the mica, which characterizes the *Vermilion group*, is wholly the result of change from hornblende, which seems to have been, or is now at least, the basic mineral of the greater hills and the massive portions. This horizon marks the earliest known appearance, in Minnesota, of basic material in the super-crust of the earth in such amount as to constitute a terrane worthy of special designation. The upper side of these crystalline schists reveals a quiet sedimentary transition into the next formation — that named Kewatin (as limited by the fifteenth report) by Mr. A. C. Lawson of the Canadian survey. There are many alternations of acidic sediments with basic, beautifully arranged in conformable stratification. In this part of the Vermilion group the rocks are characteristically hard mica schists at first, of dark color, but become graywackes as the micaceous element fades out. It is very easy to refer this mica to a changed condition of grains of hornblende derived abundantly from the disintegration

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of the basic eruptive just preceding. It is also very easy to explain its gradual disappearance, as the sediments passed into the graywackes, becoming more acidic by reference to the necessary progressive silicification of the super-crust already mentioned.

(2) The next eruption of basic materials succeeds the graywackes. It has not received any systematic name, but forms the falls of Kawasachong, in Minnesota. It is not so prominently a hill-making rock, but often appears as chloritic schists, seeking more retired portions of the topography. It is also of a lighter color, and sometimes embraces grains of free quartz which seem to be indigenous. It is prominently conglomeritic, or perhaps more correctly agglomeritic, with masses of rock like itself, though containing also, in some places, abundance of jaspilyte in fragments, as well as much chalcedonic silica in small pebbles and minute grains. This rock is prevalent at the iron mines at Tower, at Ely, and at Negaunee, and is styled, when stained by iron, "paint rock," and when not stained, soapstone and greenstone. The eruptive origin of this rock at Negaunee has been shown by Dr. M. E. Wadsworth. It stretches from Tower eastward to Ely and to Ogishke Muncie lake. It was later in date than the origin of the hematites of the formation, and seems to have terminated the Kewatin formation. It is supposed to be the equivalent of the "Serpentine group" of Dr. C. Rominger, a remarkable old eruptive of the Marquette region of Michigan. The contact of this eruptive on the graywackes about Tower is most remarkable, but cannot be described here. The graywackes and argillytes are wonderfully broken and thrust together again, and the eruptive rock seems to embrace them in the same manner as mentioned of the basic and gneissic rocks at the bottom of the *Vermilion group.*

This horizon of disturbance has been illustrated by numerous figures in the fifteenth report of the survey.

(3) We have knowledge of no formation, in the northwest, intervening between this eruptive and the unconformable overlying Animikie or Huronian. But there may have been later sedimentary deposits that are hid by this unconformable overlap. Whether there were or not, the next great epoch of basic eruption followed immediately after the Animikie, and is well described as the *gabbro or Mesabi overflow.* This is by all considerations the most notable eruptive terrane in Minnesota. The rock, while usually a well characterized gabbro, such as has been described by the Minnesota reports, and by the late Prof. R. D. Irving of the U. S. Geological Survey, varies to diabase and to dioritic rock, and apparently to a red-weathering diabasic rock. The minerals of this gabbro exhibit great variations in their relative amounts. At Duluth and at Iron lake, back of Grand Marais, the titanic magnetite so prevails that the mass of the rock, in some limited portions, is regarded as iron ore. In the region of Little Saganaga lake and in Carlton's peak the labradorite element is almost the sole ingredient; and in numerous instances, but in limited areas, about Birch lake, the mineral olivine is almost the only one present. This eruption seems to have flowed from numerous vents that occurred along the [illegible] it is now found in greatest amount. It was so copious that

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the basaltic covering which it forms is one of the most conspicuous parts of the visible geology within much of the region of the Animike. It lies not only on the slates and quartzytes of the nearly horizontal Animike, but also extended northward so far as to lie over the graywackes, schists, and older eruptives of the Kewatin. More than that, it also flowed on northward over the granitic acid rocks of the Laurentian and conceals them from sight in considerable areas, a circumstance which seems to have induced some Canadian geologists to classify it as "Upper Laurentian." This eruptive is considered to be identically the same in characters and age as the "hypersthene-rock" of Emmons which constitutes the main mass of Adirondacks in New York.

(4) The fourth, and latest, basic eruptive rock known in Minnesota is that which is seen in the great *Cupriferous formation*. That this is of much later date than the gabbro, although it lies immediately on the gabbro, is shown by the singular pudding-stones seen near Beaver bay where large transported boulders of the light-colored "labradorite rock" of Carlton's peak are embraced in a dark matrix of doleryte belonging to this eruption. Opinion is divided yet as to the age of the copper-bearing rocks of the northwest. If they are of the age of the Potsdam sandstone, these eruptives which are interstratified with the sediments, constitute the only known instance of a general outflow at that horizon and age. If they be of Mesozoic age they have their parallels in a general eruption which is found distributed from Connecticut and New Jersey to the western territories. It is the purpose of this paper only to call attention to them, as the latest is the Northwest, and not to inquire into their precise age.

THE OCCURRENCE OF CHALK IN THE NORTH AMERICAN CRETACEOUS. By ROBERT T. HILL, U. S. Geol. Survey, Washington, D. C.

EVIDENCE THAT THE MOHAWK RIVER AT A VERY REMOTE PERIOD CHANGED ITS CHANNEL OF DRAINAGE. By Dr. A. S. TIFFANY, Davenport, Iowa.

EXTRA-MORAINIC STRIÆ IN THE MISSOURI VALLEY. By Prof. J. E. TODD, Tabor, Iowa.

THE ARCHIMEDES LIMESTONES AND ASSOCIATED ROCKS IN NORTHWESTERN ARKANSAS. By Prof. FREDERICK W. SYMONDS, Arkansas Geol. Survey, Fayetteville, Ark.

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SOME PHYSIOGRAPHIC NOTES ON NORTHEASTERN MINNESOTA. By Prof. C. W. HALL, University of Minn., Minneapolis, Minn.

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PROBABLE DERIVATION OF THE TERRESTRIAL SPHEROID FROM THE RHOMBIC DODECAHEDRON. By Dr. RICHARD OWEN, New Harmony, Ind.

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SECTION F.

BIOLOGY.

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ADDRESS

BY

PROFESSOR CHARLES V. RILEY,

VICE PRESIDENT, SECTION F.

ON THE CAUSES OF VARIATION IN ORGANIC FORMS.

LADIES AND GENTLEMEN:

BUT few alternatives are left your vice president in choosing a subject for this annual occasion. With the modern world-wide activity in biology, to give a review, however condensed, of the progress and discovery of the year, would require far more time than can be given by one who yields to the pleasure and fascination of original research what little time can be snatched from the slavery of official routine and administration. Any such general review, if attempted, could not be critical or authoritative beyond the limits of one's own specialty, and the task is now well done by the combined efforts of a number whose work we get in the German and English records.

> "One science only will our genius fit,
> So vast is art, so narrow human wit."

To give a similar review of progress in one's own specialty would be to interest but a limited number. I have decided, therefore, to give expression to a few thoughts which have occupied my mind for many years, on the laws of biologic evolution, and particularly on the causes of variation in organic forms. I have been helped to this decision by the appearance, since last we met, of the "Life and Letters" of the immortal Darwin and the loss from among us of the mortal presence of our own beloved Gray. Both men, in their work, gave eminent illustration of the fact that the subjects which

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I thus take for text may be approached and elucidated from quite different roadways or beginnings. These subjects are, moreover, of still absorbing interest; for we recognize that in evolution is locked up the origin of man, just as in it are involved his present and his future, subjects which from time immemorial, or from the earliest infancy of the race, have deeply concerned him. The demonstration of the fact, the establishment of the law of organic evolution, have given fresh impetus to inquiry. To know something definite of the past but intensifies our desire to read in that past some prophecy of the future.

Evolution, as a fundamental principle in organic nature, is to-day more thoroughly established and proved in the mind of the average biologist than the Copernican theory itself.

From the time when Aristotle prophetically remarked that "Nature passes so gradually from inanimate to animate things, that from very continuity the boundary between is indistinct," through the suggestive writings of Lamarck, Erasmus Darwin, Oken, Goethe, Baden-Powell, Geoffroy-St.Hilaire, Wells, Chambers, Lyell and Spencer, the belief in biologic evolution was growing and expanding, until it ultimately blossomed in the simultaneous labors of Darwin and Wallace.

Prior to the writings of these last it was necessary to fight for the general principle, and long after the appearance of the "Origin of Species" there was a violent clash between the advocates of special Creation and those of Evolution; so that much as Darwin felt and cared for natural selection he was in the beginning more interested in settling the question of "Creation vs. Modification." The fight has continued with ever-waning forces on the part of the creationists,[1] until to-day the evolutionists are victorious and no longer under the necessity of marshalling the facts to bring conviction to the skeptical. Thus biology, the last stronghold of the creationists, has been brought into correspondence with chemistry and physics, in which the opponents of evolution had long before given way. The clearing of the smoke on this last battlefield is comparatively so recent that, in the popular mind, evolution yet applies only to the organic kingdom, and it is in this more limited sense that we, as biologists, particularly use the word, and in which I shall use it for the most part in this address. We depend for

[1] The term is used in the theological sense of creation by supra-natural means. Evolution is also creation, but by natural process.

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evidence on an immense number of well ascertained facts, so that the proofs of organic are often stronger than of inorganic evolution. Phylogeny, or the geologic succession of life, as proved by palæontology, finds its correspondence in Ontogeny, or the developmental history of the individual, particularly in its embryonic phases; while both find correspondence in Taxology, or the relationship of organic forms now existing on our globe. The correspondence, one with the other, of these three great series is one of the most pregnant facts of biology and inexplicable on any other theory than that of derivation. It is the essence of evolution that the present more complex forms are derived from older and simpler forms and that the greater the difference between groups the greater the divergence and the deeper down the converging stem or ancestry. We are justified in concluding that complete knowledge (were that possible) would permit us to trace back the origin of every organism to the simple unicellular, ancestral form. I would hardly second the strictures of a former vice president of this section on the "scientific arboriculturists," because philosophy must needs lead from the known to the unknown, and the value of a phylogenetic table depends on the knowledge and ability displayed in projecting it and on the plausibility of those parts which are not based on palæontological facts—and perhaps never can be—but which the facts of embryology suggest. Biologic evolution implies, further, what has hardly been sufficiently emphasized, (1) increase in size or bulk as correlated with the increasing diversity and complexity of organization; (2) that the most highly organized require (comparatively) the longest time for development both in the fœtal and postnatal states, and (3) that large organisms with complex structure are more sensitive to changes of condition and more liable to extinction; and this means that the larger the size and the higher the development, the fewer in number both as to species and specimens.

These principles, now so generally accepted, aside, let us at once throw a *coup d'œil* over some of the factors of evolution and see what we understand of the causes of variation and differentiation, as this is the question of questions among biologists to-day.

The essence of Darwinism as an element in evolution, viz., "natural selection," was original with several, and Darwin himself remarks, in his autobiography, that an essay in Hebrew had been published showing that the theory is contained in the Old

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Testament. He also recognized that Bronn in his "(der Natur" forestalled him in many ways. Even as ear Duchèsne wrote profoundly of the lines of variation and and showed that a genealogical order is the only one w fies the mind, all others being arbitrary; and he ventu ealogical tree based upon profound knowledge and a facts in the natural history and cultivation of the strawb principle was also fully recognized in 1813 by Dr. W. C Charleston, S. C., and in 1831 by Patrick Matthews, as tions of the "Origin of Species" set forth. Such, howe history of all great theories. They cannot be cast at panoplied and impregnable like Minerva from Jove's he discovery is usually more or less definitely foreshadowe

The publication of the "Origin of Species," however, new epoch in biology and the work has profoundly influe ern thought. Yet Darwin's fame rests just as firmly vast structure of facts which he so successfully brough in his various writings, as it does on his theories; and ha propounded the theory of Natural Selection, his writings immortalized him, for they form an encyclopædia of wel data for the naturalist, the agriculturist, and the stoc He threw the light of his genius into recesses formerl and opened new vistas through old problems which had defied elucidation.

It would require volumes even to indicate the extent acter of the literature upon evolution since the appear "Origin." The proceedings of this section of the Amer ciation during a quarter of a century have been, in a me ical of the proceedings of like bodies the world over, and a record of the discussions and of the progress of thoug perience in this direction. We have every reason to b the work of American biologists as illustrated in this r notwithstanding the vagaries of a Swallow, and the mo serious opposition of a Dawson, belief in the derivativ species has steadily gained among biologists and now i those whose work and word are worthy of consideration be proud, also, of the demonstrative proof which memb section have brought to bear upon the general theory, the newer thought and far-reaching generalization or other members of the section.

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In looking over this record two things strike me as worthy of further consideration. On the one side there has been a disposition to widen the meaning of the term "Natural Selection" so as to include the cause, or causes, as well as the method, of variation and modification. On the other side, the tendency has been to the opposite extreme or to limit the application of the term to the mere selection of the fittest, so that it becomes but the expression of a common and easily observed fact in nature, without involving any of the more fundamental principles of evolution. It becomes merely a means or method and in no sense a cause of modification. Some writers even go so far as to insist that while it is all powerful in originating genera, *i. e.*, in producing adaptive structure, it has little or nothing to do with the production or origination of species and they would thus render the very title of Darwin's greatest work a misnomer.

It may not prove unprofitable to note what the "Life and Letters" have to say upon this question, and to see what limit, if any, Darwin himself placed upon the term. It is of prime importance that we use it in as accurate a sense as possible, since it has played such an important part in the literature of, and expresses such an important factor in, evolution. The book is most interesting and suggestive; for we not only get from it an insight into the persistent and laborious effort which resulted in Darwin's enduring fame, and left so deep an impression on the scientific work of his generation; but we come to realize how he labored in giving his thought that forceful, logical, yet simple expression which had so much to do in making his work popular; how the candor of his argument and statement was but the reflex of the candor and honesty of his mind. We learn to appreciate more fully the vast range of knowledge he possessed of scientific fact, both from personal experience and authority, and how he bent it to one great end. We come to love him for his many beautiful personal traits; his noble character; his simplicity; the courage with which he bore up under bodily ailment; and for his humanity to animals, which is well brought out by interesting anecdotes given by his son. We honor him for his strong feeling and sympathy with suffering, both in man and beast; for his horror at the suffering of slaves, which inclined him strongly to the Union side in our Rebellion but did not blind him to what, from the average English standpoint, were the political issues at stake; just as his sensitiveness to the suffering of

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animals did not warp his position on the question of vivisectio which he believed to be justified for investigations in physiolog In scanning the pages of his personal record we come to reali fully that

> "His life was gentle; and the elements
> So mixed in him that nature might stand up
> And say to all the world—
> This is a man!"

But aside from the insight which the book gives into the lovab character of the man, and of his method of work, it is replete wi thought and fact, and may be looked upon almost as an append to the "Origin." Let us see, therefore, what light it throws on t question we have propounded.

The actual causes of variation may be few or many—remote immediate; but their discovery or non-discovery no more affec the principle of natural selection than the difficulty in elucidati the causes of gravitation affects it as one of the grandest disco eries and generalizations of our age. We may come to understan and are already able to elucidate some of the proximate cause but the consideration thereof inevitably leads us back farther a farther to the great First Cause, and Darwin's work would nev have had so profound an influence had he, instead of basing his th ories on demonstrable and experimentive fact, been led into t more speculative realms of causation. Not but that he was i tensely interested in the causes of variation; for we have his ow words and those of his son to show the ever-present desire in h mind to learn something thereof. But he avoided consideration them in the same way that he avoided speculation on the origin life itself, seeing clearly, no doubt, that both questions lead ul mately to Infinite Causation and that this is beyond man's fini comprehension, in his present state of development, at least.

In a letter to Lyell, September 12, 1860, in response to a que tion why rodents have not become more highly developed in Au tralia, he says: "I feel that our ignorance is so profound, why o form is preserved with nearly the same structure, or advances organization or even retrogrades, or becomes extinct, that I canno put very great weight on the difficulty." Again, Feb. 23, 186 he says: "With respect to Bronn's objection that it cannot be show how life arises, and likewise to a certain extent Asa Gray's rema that natural selection is not a *vera causa*, I was much interested b

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finding accidentally in Brewster's 'Life of Newton' that Leibnitz objected to the law of gravity because Newton could not tell what gravity itself is.* * * Newton answers by saying that it is philosophical to make out the movements of a clock, though you do not know why the weight descends to the ground."

We may now consider the question of natural selection itself, and see whether, as the expression of a principle, it may not be more strictly defined than it was by Darwin himself.

We find in his correspondence with Wallace that the latter states that the term "survival of the fittest" is the plain expression of a fact. Natural selection, on the contrary, is a metaphorical expression of it, but to a certain degree indirect and incorrect. The great objection which Darwin urged to the term "survival of the fittest" was that it could not be used as a substantive governing a verb, which obliged Spencer himself continually to use the term "natural selection." Darwin recognized, however, the force of the objections to the term, and yet it would be difficult to find a better, and his final preference, after long deliberation and correspondence with men like J. D. Hooker, has justified his judgment. Wallace noticed that Darwin had used the term in two senses: *first*, for the simple preservation of favorable and destruction of unfavorable variations, in which case, according to Wallace, it is equivalent to the "survival of the fittest," and *secondly*, for the effect of the change produced by this preservation. In his autobiography, Darwin says: "But it was clearly evident that neither the action of the surrounding conditions nor the will of the organism (especially in the case of plants) could account for the cases in which organisms of every kind are beautifully adapted to their habits of life." Nothing can be more characteristic than the following in his long letter to Lyell, October 11, 1857. "It has taken me so many years to disabuse my mind of the too great importance of climate —its important influence being so conspicuous, while that of the struggle between creature and creature is so hidden—that I am inclined to swear at the North Pole and, as Sidney Smith said, even to speak disrespectfully of the Equator." In a letter to Victor Carus we find him inclined to place more value on the definite action of external conditions, and to infer that single variations are of less importance in comparison *with individual* differences than he formerly thought.

I recollect well, while visiting him in the fall of 1871, that he

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expressed very much the same views which he has expressed in a letter written about that time to Huxley, in which, using the illustration of a pendulum, he says: "The pendulum is now swinging towards our side and I feel positive that it will soon swing the other way." He realized that there would be oscillations in the popularity and general acceptance of his views and especially as to the part of natural selection as an originating power.

Thus his own views as to the value, scope and bearing of natural selection, varied to some extent, and he used the term in two different senses. In the broader sense, as used by him, and by many of his followers, notably in this country by Fiske, Morse, Marsh, etc., it is a great principle of modification that includes both the fact of variation from whatever cause or causes and the explanation of accumulative divergence along beneficial and adaptive lines. It involves the Malthusian struggle for existence, not only among the organisms themselves but with the elements and the environment.

It is plain from Darwin's own writings that a term to express the principle was not easily found and the difficulty was doubtless due to the uncertainty that existed in the author's mind, as it has existed in the minds of his followers, as to the exact limitations of the principle. The term is happy in my judgment, because it has permitted the focussing of definition by subsequent elucidation. Darwin could but feel that "Wahl der Lebensweise," as a German translation, hardly expressed his opinion, and he was right; "natürliche Zuchtwahl," the later translation adopted, being far preferable.

As propounded by him, natural selection deals essentially with the variation of the individual under like conditions, as distinguished from the variation of the type under change of environment. He impersonates by the term an *ensemble*, *i. e.*, a number of innate conditions of variation. The principle is, in fact, based upon the Leibnitzian axiom "*Natura non agit saltatim*," and it finds a counterpart in the facts of artificial selection induced by man which, in reality, led Darwin to adopt the term to express selection by nature. But here it must distinctly be borne in mind that by Nature, though it is difficult to avoid personifying it, he meant "only the aggregate action and product of many natural laws,—and by laws only the ascertained sequence of events. He found it difficult to admit of any personality or designer in any way using natural

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selection for designed ends, so that the comparison with artificial selection by man lacks in one most important particular; but we may recur to this point later on. Natural selection is a great principle, the promulgation of which revolutionized biology. It is a *modus operandi* of derivative genesis, embodying two somewhat opposing laws, namely, heredity and adaptation; the former for the most part conservative and tending to cause organisms to hold to the past, the latter progressive and tending to cause them to diverge or ramify. It is a *quo modo* of succession, but it implies no necessary tendency to progression, however much such progress may be indicated in the general history of evolution. Certain simple conditions of life may have persisted from before the Silurian age to the present day, and the one primordial prototype of all living and extinct creatures may still exist so far as natural selection is concerned.

It is a principle universal in its action, explaining one important mode of modification and differentiation of forms, especially among higher animals or where the interests of highly endowed or organized beings most strongly interact to give it effect. It must be less effective among lower organisms, where external conditions are evidently prepotent in inducing not only variation but specific modification. Natural selection, therefore, does not satisfy us as an explanation of the original differentiation of the great classes, and it was perhaps a certain recognition of this fact which caused Darwin to pause on the safe side of their differentiation and not endeavor to explore the deeper mysteries beyond. Yet after all it is among these lowest forms that the key to the explanation of the more important factors in evolution must be sought.

The Darwinian, therefore, who would give fullest expression to the teachings of the master, employs the term in a broad sense as the expression of a principle in nature which explains how the fittest have come to be preserved, and hence the mode of formation of species. The "formation" would have been a happier expression than the "origin" of species, but not so good a catch-title, and we should never forget that the sub-title of the immortal work, viz., "The preservation of favored races in the struggle for life," more fully expresses the author's meaning. By its too zealous advocates natural selection has been used to explain phenomena due to other causes. This is, however, a danger that all great discoveries encounter; they are made to do service for which they were not originally propounded. But the opposite tendency, when car-

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ried to extreme, is equally unjustified and would obliterate n
selection as a factor in evolution.

Spencer's expression the "survival of the fittest" has ofte
used as synonymous with natural selection, to the detrim
the latter; for while all must recognize the aptness of the te
a somewhat tautological expression of the result, it can ne
made to cover the principle involved in the Darwinian ter
is an explicit and forceful expression of the fact and in nc
of the theory. Natural selection deals not so much with t
vival of the fittest as with the destruction of the unfit. It ex
a cause of differentiation or formation of species and higher g
in a sense in which the "*survival* of the fittest" does not, h
little either term may explain the causes of variation *per se*
origin of the individual variation. It operates under subj
taking advantage of variation otherwise initiated; or, to use
cer's language, it expresses an effect of the mode of coöp
among causes. We are justified, therefore, in saying that
selection is the essence of Darwinism and is a fundamenta
ciple in organic evolution based on (1) individual variati
(2) the struggle for existence and preservation of the mos
petent. Other factors of less importance help to give it p
It is based upon the facts as they may be observed, and the
superstructure is built upon the innate variability of indiv
irrespective of conditions. The difficulty of getting at the
diate cause or causes of this individual variation led Da
consider it promiscuous or aimless, though he wisely avoids
it lawless. He felt, as we have already seen, that there were
and that of the majority of these we were ignorant. In
words, "we can so rarely trace the precise relation betwee
and effect, that we are tempted to speak of variations as
arose spontaneously. We may even call them accidental,
must be only in the sense in which we may say that the fr
of rock dropped from a height owes its shape to accident."

I have always had a feeling, and it has grown on me
creasing experience, that the weak features of Darwinism an
of natural selection, are his insistence (1) on the necessity c
modification; (2) on the length of time required for the ac
tion of modification, and (3) on the absolute utility of th
fied structure. I think that Darwin laid altogether too muc
on these points, and that while, in the main, insistence

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is justified, a too strict adherence to them weakens natural selection as a true expression of the phenomena of modification. This is particularly true of lower organisms among which, as we have already seen, natural selection has been and is necessarily less potent than among the more highly organized and complex, from which, especially under domestication, Darwin drew most of his evidence.

Whatever influence we may attach to environment and external conditions, it is self-evident that they alone have not been sufficient to induce the wonderful variety of life existing upon the globe today. Indeed, so far as natural selection implies necessary utility, necessary adaptation to surroundings, it is, as I have said, defective. We know very well that introduced species from one continent to another, or from one country to another, have proved better adapted to the changed conditions than the indigenes or endemic forms. This is readily comprehended on two grounds; *first*, that species which have, in the course of time, experienced a greater struggle among themselves in large areas, have an advantage over those in more limited areas in which the struggle has been less intense; *secondly*, that species which have accommodated themselves to the changes in life conditions which civilized man induces, have a great advantage when, following man's migrations, they are brought into competition with species which have not yet been subjected to such conditions. Again, no valid reason can be urged why, within a given area, one species predominates over another in so far as mere adaptation is concerned. The influences of environment alone would tend to unify the fauna and flora of a given region. Theoretically, so far as climate and physical conditions are concerned, there is no reason, through regions where these are uniform, why a single animal should not prevail to the exclusion of all others, providing it was vegetarian, or that the particular plant which furnished food to such an animal should not prevail to the exclusion of all others. The hickory and the blade of grass must be considered equally adapted to the environment with the oak, and so on all through the multifarious forms of both vegetal and animal life: so that this diversity of form can best be explained by some principle like natural selection, and by the interrelation and interaction of organisms and the struggle between them for existence. This is illustrated in many directions. To take a striking example: no one doubts that if the larger carnivora

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of Europe and Asia were introduced into Australia, the marsupials would soon have to give way and could survive only by the acquisition of special functional modifications and larger intelligence such as we find in our opossum. Yet it would be folly to conclude that the marsupials are less well fitted to the physical conditions which obtain in Australia than their introduced exterminators.

From what has preceded, we are, I think, justified in rejecting the interpretations of both extremists as to the scope and meaning of natural selection. It cannot be debased to the mere expression of the universally observed fact of variability; yet it must be restricted, because it not only implies something to be selected, but its promulgator limits its scope to the selection of something that is useful. As a philosophy it considers only processes and leaves remote origin and cause untouched. The following limitations are probably justified to-day and will help to more exact use of the term.

1. It deals only with individual variation from whatever cause, and should not be applied to simultaneous variation in masses.

2. It deals only with variations useful to the organism in its struggle for existence, and can exert no power in fixing the endless number of what, from present knowledge, we are obliged to consider fortuitous characters. It cannot perpetuate useless organs; nor those of a vestigiary or obsolescent character.[1]

Even with these restrictions, the principle is far-reaching and profoundly important; but it quite fails to account for many of the most interesting manifestations of life that are obviously not necessary or life-preserving, of which many will occur to every one, such as, among lower organisms, many superficial details of structure; or, as among higher organisms, odd habits and customs, playful instincts, ethical traits, etc. Its limitations must be narrowed in proportion as we come to understand the other laws of modification and the causes of variation in masses. Let us briefly consider some of these causes.

While, as already stated, the consideration of this question inevitably leads to Ultimate Cause, there is no more fascinating or profitable field of investigation than that leading to the proximate cause or causes of variation. We are not content to rest the case where Darwin did by recognizing variation as an inherent principle

[1] In the literature of evolution, these are usually termed rudimentary, but, strictly speaking, this term should be applied only to nascent or incipient structures.

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in organic forms, or to beg the question by saying that it is as much a necessity of life as natural selection itself. Let us, therefore, discuss these causes in the light of recent experience and experiment.

We soon find that they admit of a certain amount of classification, the minor divisions of which, as in all systems of classification, more or less fully interlock or blend. They fall, however, into two chief categories, viz. (1) external conditions or environment, which are, at bottom, physical, and (2) internal tendencies or promptings, which are, at bottom, psychical. We shall also realize more fully that there is good reason for the varying importance which has been placed on natural selection because it represents a broad principle, based on the outcome of both these categories, but particularly of the latter. Its value is not a fixed one, and must needs change with the increase of exact knowledge of the other factors, and did in fact change in the mind of its originator. We shall further find that there are laws of evolution which permit of formulation and expression, and which have influenced or controlled the mode of variation, but which must not be confounded with or included among the causes of the variation proper, though here again, the line between the two kinds of factors is not always easily defined.

The conditions of organic modification may, therefore, roughly be classed as (A) external and (B) internal, and these may be almost indefinitely subdivided. The former class includes (1) *physical* and (2) *chemical* forces and in a broad way may be said to induce modification independently of natural selection, however much this may act with them as a secondary cause. Certain prominent features of the physical forces are worthy of mention: as light, temperature, water (stagnant, or in motion), climate (under which term may be included meteorologic phenomena, as electricity, atmospheric pressure, etc.), mechanics (gravitation, wind, stress, friction, etc.) and geographics (migration, isolation, etc.). The chemical forces may be considered under the subdivisions, aquatic, atmospheric, food and soil. In class A may also be included (3) *vital*[1] or organic force in so far as this is concerned with the in-

[1] I am well aware that this term is much tabooed among a certain class of the more materialistic evolutionists, but I use it here for want of a better, and because as an expression of one form of manifestation of force, it has as much a classificatory value as physical or psychical.

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teraction of organisms, and it is seen thus to link the two great classes. The second class (B) includes (1) *physiological* and (2) *psychical* forces. Prominent among the former, as causes of modification, are worthy of mention those connected with genesis itself: as heredity, physiological selection, sexual selection, hybridity, primogenital selection, and what I would call sexual differentiation, and philoprogeneity. Among the latter may be included use and disuse, individual effort, etc.; and last, but not least, the emotions.

As already stated, any such classification of the forces at work in organic evolution must be more or less arbitrary and artificial. Fundamentally also, they are, perhaps, convertible terms—unifiable — one. But some such arrangement as that here suggested serves to simplify discussion.

Now with the limited definition given to natural selection, all the forces in class A act independently of it, while the rest are more or less fully aids to its action. Time will not permit of much detailed consideration of the physical and chemical forces. Nor is such consideration necessary; for their influence, as Darwin well remarked, is obvious. Fundamentally, they must needs limit and control all manifestations of life of which indeed, on evolutional grounds, they are the material basis. Change of physical environment may affect function first and chiefly, but this involves change of form and structure which are integrated by heredity. The surface of the earth and the waters upon it and the atmosphere above it have necessarily conditioned the chief modes of animal locomotion as swimming, flying, crawling and walking, while the five great classes of vertebrates find the explanation of their structure, as J. B. Steere pointed out at the Ann Arbor meeting, in the conditions of life in water, in shallows, in the air, on land and on trees and rocks.

External Conditions.—By external conditions or environment, we include all influences on organisms which act from without, and in carefully considering them we shall find it difficult to draw the line between those which are really external and independent of any motive or inherent tendency in the organism, and those which are not. Hence, the general term "External Conditions" is resolvable into various minor factors. Considering the influences as a whole, we find that in the 1844 essay, or sketch, Darwin gave more weight to them as producing variations, and as modifying habit, than he

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did in the "Origin"; yet we all know that he felt convinced when this work was first issued, that natural selection was the main, though not the exclusive, means of modification. Before his death, he was again led to attach greater importance to them. As late as March, 1877, he wrote to Neumayr, of Vienna, that "there cannot be any doubt that species can be modified through the direct action of the environment. I have some cause for not having more strongly insisted on this head in my 'Origin of Species,' as most of the best facts have been observed since its publication." He was led to this modification of his views by Neumayr's essay on "Die Congerien," and by Hyatt's work in showing that similar forms may be derived from distinct lines of descent. In his correspondence with Huxley, Darwin remarks that one point has greatly troubled him. If, as he believed, accidental conditions produced little direct effect, "What the Devil determined each particular variation? What makes the tuft of feathers come on the cock's head, or moss on the moss rose?"

It is quite plain, indeed, that subsequent to the publication of the "Origin," and especially in 1862, in his correspondence with Lyell, Darwin was inclined to give more power to physical conditions, and, in fact, was wavering in his mind as to the force of the different influences at work. In his letters to Hooker in 1862, the same tendency may be noted and the preparation of the "Variation of animals and plants, under Domestication," led him to believe rather more in the direct action of physical conditions, though he seemed to regret it because it lessened the glory of natural selection and, to use his own language, "is so confoundedly doubtful." One can plainly trace from the correspondence how, prior to the publication of the "Origin," he more and more, as his facts accumulated, and as the theory of natural selection grew upon him, relegated to an inferior place the influence of environment; while, subsequent to the publication of that work, and up to the time of his death, the tendency seemed to be in the opposite direction.

Many eminent workers have differed greatly from Darwin in the influence allowed to these external conditions, and this is particularly the case with our American writers. Indeed, no one can well study organic life, especially in its lower manifestations, without being impressed with the great power of the environment. Joseph LeConte speaks of the organic kingdom lying, as it were, "passive and plastic in the moulding hands of the environment." Leidy,

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Wyman, Clark, Packard, etc., have insisted on the influence o physical conditions. Baird and Ridgway on geographical distribu tion, Whitman on concrescence, Hyatt on gravitation, Cope an Ryder on mechanical stress, have all published valuable corrobora tive evidence; while many other writers have added their view and testimony which have been admirably condensed by Professo Morse in two addresses before this Association. Allen demon strates plainly the influence of climate and temperature in directl inducing specific changes. Weismann, in his remarkable "Studie der Descendenz Theorie," concludes that differences of specifi value can originate only through the direct action of external con ditions, and that allied species and genera, and even entire families are modified in the same direction by similar external inducin causes. In Semper's "Animal Life" (1877) we have the best sys tematized effort to bring together the direct causes of variation, an no one who has read through its pages can doubt the direct modi fying influences of nutrition, light, temperature, water at rest an in motion, atmosphere still or in motion, etc., or question his con clusion that no power which is able to act only as a selective an not as a transforming influence, can ever be exclusively put fort as a *causa efficiens* of the phenomena. Kölliker, in 1872, wrote "Manifold external conditions, when they operate on eggs under going their normal development, on larvæ or other early stages o animals, and on the adult forms, have produced in them partly pro gressive, and partly regressive, transformations," and recognized as most important forces, nutrition, light and heat. Indeed, the direct action of environment must have been, as Spencer puts it "the primordial factor of organic evolution."

In so far as it offers evidence, entomology confirms the conclu sions of the writers in other departments of natural history, abov referred to, and offers a host of most conclusive proofs of the di rect action of the physical and chemical factors which I have enum erated. Justice, however, could not be done to the facts withi the limits of an address of this kind, and I pass on to some of the other factors.

It is among what I have called the vital or organic condition of variation that natural selection has fullest sway, and as they have been so ably expounded by Darwin and others they may be dealt with in few words.

Interaction of Organisms.—The productions, as a whole, of greate

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areas will, whenever they get an opportunity, conquer those of lesser areas, and in this broad sense, the interaction of organisms may be said to have had no special modifying power, however great its influence may have been, and is yet, in inducing the survival of the fittest, or in bringing about the present geographical distribution of species. The consequence of enforced migration and of isolation are best considered when dealing with the physical conditions, because they must influence modification of masses rather than of individuals, and either substitute one type for another or remove competing or differentiating influences. But in the more restricted sense, *i. e.*, the interaction of organisms occupying the same ground—the struggle for existence, in other words, between direct competing organisms—is a prime Darwinian factor of modification, and a whole volume of illustrations may be drawn from entomology; for in no class is the contest more severe, whether with plants, or with other animals, or with one another, than in insects. In no other field of biology, for instance, have the physical conditions resulted in such infinite diversity of form and habit fitted, whether for earth, air or water, and often for all in the same individual; so, also, in no other field, is parasitism carried to such a degree, or are the purely adaptive structures due to this interaction so varied or so remarkable. The entomologist who goes beyond the "dry bones" of his science is inevitably a Darwinian.

In this category must also be included that interrelation between insects and plants which has eventuated in the so-called carnivorous plants, and that still more wonderful interaction between flowers and insects by which each has modified the other, and the facts of which have been so untiringly observed and so well set forth by a number of writers from Sprengel's day to this, and by none more successfully than by Darwin himself. These are plainly inexplicable on external conditions acting on masses alike and are meaningless enigmas except on the theory of natural selection, or some supra-natural and dogmatic gospel.

We are thus led, through this last, from the external to the internal factors in evolution, or those of a physiological and psychical nature. In these, natural selection is the key which, so far, best unlocks their meaning and shows how they have acted in the formation of species and the less fundamental of the great groups. In considering them it is hardly necessary to discuss their relative importance as compared with the external conditions, though it

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may be remarked that they are the factors which have induced great variety of adaptive forms and minor differentiations, wh the external conditions have governed the formation of the gr and more comprehensive types of structure.

Darwin was led to give more importance toward the end than had originally done, to some of these internal factors and especia to functionally-produced modifications. In the "Descent of M he says that he did not sufficiently consider variations "which far as we can at present judge are neither of benefit nor injurio and this I believe to be one of the greatest oversights I have detected in my work." And in the sixth edition of the "Orig he frankly admits that he had omitted in other editions to consi properly the frequency and importance of modifications due spontaneous variability. He further refers to morphologic dif ences, which may have become constant through the nature of organism and the surrounding conditions rather than through n ural selection, since they do not affect the welfare of the speci In short, Darwin's views kept pace with the investigations of day and tended in the direction of restricting rather than wid ing the influence of natural selection. But, as Romanes, and pecially Spencer, in his Factors of Evolution, have fully sho Darwin's position on this subject, I may pass over the detail.

INTERNAL CONDITIONS—*Physiological.*—*Genesis* itself is the f and most fundamental of all causes of variation. The philosop of sex may, indeed, be sought in this differentiation, as the ac mulated qualities in separate entities when suddenly conjoined commingled inevitably lead to aggregation and heterogeneity— other words, to plasticity or capacity to vary. Genesis, as a f damental factor in evolution, may be more intelligently conside under some of its subordinate phases, as heredity, physiological lection, sexual selection, primogenital selection, sexual differen tion including philoprogeneity, hybridity, etc.

Heredity, as expounded by the ablest biologists and as exem fied in life, is a puissant factor in evolution and though essenti conservative must, through the marvellous power of atavism, t to increase individual variability. The subject has been too v considered by Darwin and his followers to justify further discuss of it here. As a cause of variation, heredity must, however, h less and less influence as we go back in the scale of organized ings; for it cannot well come into play in agamic or fissiparous

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production, a fact which has given the abiogenesists one of their strongest arguments, since it is difficult to understand how, for instance, the monera of to-day could have descended without change from the primordial form.

Physiological Selection.—Physiological selection, as suggested by Mr. Catchpool and as expounded by Romanes, is undoubtedly a veritable factor in evolution, and while giving us another link in the chain of evidence as to the causes of differentiation, lessens in but very slight degree, the overwhelming force of the argument for natural selection. It adds, rather, an important element in the evidence therefor and may be classed as a subordinate cause of differentiation. Romanes' theory is based upon the argument that differences, such as constitute varieties and species in their commencement, would not be preserved by natural selection unless useful, but would be lost again by cross breeding with forms like the parent, and which had not varied, except upon some hypothesis like that of physiological selection. This could not be prevented except by migration. This difficulty is a general one, was argued by Darwin himself, and has been felt by all Darwinians. The reproductive organs are extremely variable and sterility may occur not only between species, but between races and varieties and often between individuals. Physiological selection tends to form varieties by peculiarities in the reproductive system of individuals which render them unfit for perfect coition, or cause them to remain more or less sterile, with other individuals which have not the same peculiarities.

The exact reasons are recondite, and the whole subject difficult of demonstration except from the results, since changes in the reproductive organs are not easily observable. Romanes believes this sterility to be incidental to variation and hence one of the chief causes of the accumulation of such variation. Wherever there has been modification of the reproductive organs introducing incompatibility between two individuals, even where there has been no other change or variation, we have a valid cause of differentiation which in its consequences must be important. Compatibility or fertility between individuals is of the very essence of selection. Natural selection implies that this sexual divergence is subsequent to or coincident with divergences in other directions; physiological selection, that it antecedes them. To put the case of Romanes more fully, we will suppose that among the natural variations there occasionally

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occurs something to affect the reproductive organs in such wise as to produce incompatibility, *i. e.*, incapacity of one individual with another of the parent type, to unite, or sterility of such union, while it remains fertile with the variation of its own kind. This theory of course implies variation in the reproductive organs, or departure from the parental type, in at least two individuals of opposite sex simultaneously, and with this admission, for which we are justified in facts, physiological selection will preserve many peculiarities which need have no necessary connection with the exigencies of life.

The change may be in the organs of reproduction, introducing sexual incompatibility, or it may be due to other causes, as, for instance, the time of flowering in plants, or the season of heat in animals. Even the element of scent becomes important here, as my friend J. Jenner Weir has suggested, since it may influence sexual relationship, so that the very excretions of the body, which vary with individuals, must be allowed their part. Francis Galton has indicated a modification of Romanes' views, viz., that the primary characteristic of a variety resides in the fact that the individuals who compose it do not care to mate with those outside their pale. Incipient varieties are thus thrown off from the parent stock by means of peculiarities of sexual instinct which prompt what anthropologists call endogamy and check exogamy or marriage without the tribe or cast. This is a very good anthropological illustration of how physiological selection may begin.

Natural selection preserves the individuals best adapted to life conditions by destroying the less fit. Physiological selection may be said to preserve differences which have no necessary connection with the necessities of life. Neither touches the origin of the variation, but both express laws thereof or methods by which it is accumulated. The inherent tendency to vary, whether in external or adaptive structure, or internal or reproductive character, is simply an observed fact, the causes of which we are endeavoring to analyze.

Physiological selection is remarkably exemplified in insects and probably in no other class are the modifications which may be attributed to it more easily studied; for in no other class are the genitalia of the male so variable or so complex. There has so far been no attempt to homologize the different parts in the different orders of insects, so that they have received different names ac-

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cording to individual authors. Ordinarily there are two pairs of claspers, themselves very variable, associated with sundry hooks and tufts of hair. There are families, as in the Cecidomyidæ, among the Diptera, in which many species are almost, and others, absolutely, indistinguishable except by the differences in the male genitalia. In all other orders there are an immense number of forms which can only be distinguished by a careful study of those organs. Descriptive entomology to-day, which does not take account of these organs, is, in fact, almost valueless, and we must necessarily assume that where there is differentiation of structure in these important parts it implies a corresponding modification on the part of some associated female even where no other differentiated characters are to be detected, and upon Romanes' law such must be looked upon as physiological varieties and will be counted good species in proportion as the differentiation involves other observable characters or as their life habits determine.

Sexual Selection. — The part of sexual selection in inducing variation may next be considered. While it is evidently at the bottom of the diversity in sex so common among many animals, it is difficult to see how it can play any very important part in the differentiation of species, except on the hypothesis that the greater the differentiation between the sexes the greater the tendency to vary in the offspring. In no class of organisms is this factor more notable than in insects, and volumes might be written to record the interesting and curious facts in this class alone. As a general rule it may be said that with insects, as with other animals, it acts chiefly in inducing secondary sexual characteristics in the male, and in simplifying the characteristics of the female. Nowhere do we find greater contrasts between the sexes, involving almost every organ, both colorationally and structurally. Where color is affected, the greater brilliancy almost always belongs to the male sex, as in birds. So where song or sound is employed to attract, the sound organs are either peculiar to, or most highly developed in, the males. As in higher animals, also, so in insects, we find offensive organs highly developed in the male, and either lacking, or but partially developed in the female, wherever the struggle for the possession of the female is by force, or strength. It has evolved scent organs in various parts of the body, causing modification, especially in the Lepidoptera, of either the membrane of the wing, or the scaly covering; it has induced profound modification in the

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structure of the legs, whether the anterior, middle or posterior pair, and whether in the whole member or some part of it, or in its covering. The subject has been so fully treated by Darwin, however, that it is not necessary to elaborate it further in this connection. Strictly speaking, it may be said to act in two ways, viz.: by conflict of the males for possession of the female, or by attractiveness, the former being most conspicuous among mammals, the latter among birds, and both coming conspicuously into play among insects. It is rather difficult to define the limit of sexual selection as a factor in evolution, but I would not confound it with another factor, not hitherto generally recognized, but which I think must be all-powerful, namely, sexual differentiation.

Sexual Differentiation.—It seems evident that the mere differentiation of sex in itself has been an important element in variation. The principle elaborated by Brooks as a modification of the theory of pangenesis is a good one, and in the main the male may be said to be the more complex and to represent the progressive, and the female the more simple and to represent the conservative element in nature. When the conditions of life are favorable, the female preponderates, and exercises a conservative influence. When the conditions are unfavorable the males preponderate and with their greater tendency to vary induce greater plasticity in the species, and hence greater power of adaptation. Sexual differentiation may, I think, be used to include many other variations and differentiations not otherwise satisfactorily accounted for, and to express the law of the interaction of the sexes upon one another, inducing great differentiation entirely apart from the struggle of the males for the possession of the females, or the struggle for existence. Among insects, particularly, though the same is true among other classes, we find many illustrations of this that can hardly be explained by the other forms of selection.

A few of the more notable in Hexapods may be instanced, as the degraded form of the female in Stylopidæ; in very many Lepidoptera and Coleoptera; in the females of the Coccidæ, in Homoptera, etc. In most of these cases it is the female which has been modified, without any very special modification in the male, though it is a general rule that in proportion as the female is degradational and stationary, the organs which permit him to find her, or to mate with her, and particularly the antennæ, eyes and genitalia are profoundly modified and complex. This is especially noticeable in

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the Psychidæ where the female remains in her case, a mere mouthless, eyeless, legless and wingless grub, and the male has most complex and ramose antennæ and complex genitalia. Another remarkable instance may be cited in the Lampyridæ, where we find every degree of degradation in the female, from partial wings to no wings at all, accompanied with increasing complexity of eyes and antennæ in the male, until at last in the Phengodini the female is so larviform that she can hardly be distinguished from the true larva. In all these cases the female has been as profoundly modified as, and often more so than, the male, and in the latter case a phosphorescent power has been evolved so that the attractiveness, as in the human species, is rather on the female side. Again, in the case of Corydalus, in Neuroptera, the profound modification of the jaws in the male into prehensile sickle-shaped organs is to be explained rather on the interaction between the sexes, and the facility the modification offers for coition, than upon sexual selection in its proper and restricted sense.

In this category must also be included the influence of *philoprogeneity* which has modified the female rather than the male either in the primary sexual organs for offence or defence, as in the sting of the aculeate Hymenoptera; or in the secondary sexual characters, as in the anal tufts of hair, secretory glands, etc., of many Lepidoptera; or in modification of various other parts of the body exhibited in various orders of insects to facilitate provision for their young, whether in the preservation of the eggs or the accumulation of food for the future progeny. A notable instance of how far this may be carried is furnished by the female Pronuba, where the ovipositor and the maxillæ are so profoundly modified as to make her unique in her order. Sexual selection can have little to do with these modifications, cases of which might be multiplied indefinitely; nor can they be fully explained by natural selection, in the restricted sense in which we have proposed to use it; nor by physiological selection.

In this category might also be included modification which has resulted in the various forms of females which obtain in the same species, fitted whether for agamic or sexual reproduction and which are far more readily explained on the theory of sexual differentiation aided by environmental influence, especially food and temperature, than upon any other.

Hybridity.—The subject of hybridity has been fully discussed by many and by no one more ably than by Darwin himself. It

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has generally been assumed that the hybrid of any two species i sterile, and, in fact, hybridity has been looked upon as one of th best tests of specific value next to genesic incapacity. The as sumption finds its greatest support in genesis among the highe animals, and the most thoroughly differentiated species; but th whole subject becomes complicated as we descend in the organi scale, and hybrids between what naturalists generally separate a good species are far more frequently fertile among plants and lowe animals than was formerly supposed; while physiological selectio as we have just seen, may render genesis impossible, or at lea prevent it, between varieties and incipient species. In this ligh hybridity becomes an important factor in the modification of spe cies. Unnecessary importance has been given, in my judgmen to the fact that domestic and wild species differ in the fertility o their crosses. It is assumed, for instance, that all the know breeds of domestic dogs would be fertile *inter se* and produce fe tile crosses. It seems to me, on the very face, a preposterou proposition and that many of the breeds of domestic dogs are a distinct specifically, and even generically, so far as this test i concerned, as they are in structure and other characteristics. Wh for instance, has ever known or heard of a cross between a bu dog and a lap dog, or between a Newfoundland and a black an tan? The difference in size alone would seem to render such cross, if not a physiological or a physical, at least a practical, im possibility; so that hybridity among domestic animals tends t essentially the same result as among wild animals, and confirms it importance as a differentiating factor.

Having thus summarily indicated those factors of evolution as sociated with genesis and which are essentially physiological, hov ever much psychical phenomena may coöperate, we may touch upo the more purely psychical factors or those pertaining to the growt and use of mind, employing the term to express those neural phe nomena traceable to the medium of the brain. Their importance i evolution increases with increasing cephalization and complexit of nerve system. For the present purpose, however, it is with th objective side of psychology or what may be called psycho-phys ology that we must deal.

Psychical—Use and Disuse.—Full consideration of the effect o use and disuse involves a discussion, not only of the question o the transmission of acquired structures, but of the influence of in dividual effort and of necessity, *i. e.*, a consideration of the esse

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tially Lamarckian factors in evolution. The occasion will not permit me to do full justice to these subjects. That functionally-produced modifications are inherited was the great assumption upon which Lamarck founded his theory of evolution. Many able naturalists have insisted on it, and in my judgment there should no longer be any doubt whatever of the fact, not only so far as grosser structure is concerned, but brain structure likewise. No question is of more moment in the whole range of biology and especially biologic philosophy, and Spencer has well pointed out that on the answer to it will depend largely the sciences of psychology, ethics and sociology. Weismann, Lankester and others deny hereditary power in such modifications, the former believing that hereditary modification can result only from changes in the *germ plasma*, *i. e.*, are virtually congenital. Natural selection, according to this view, plays upon the germ plasma; but I have never been quite able to comprehend how this view, even if established, militates against the transmissibility of acquired modification, for, whatever theory of heredity we adopt, it shows us rather the manner of the transmission and therefore confirms its possibility. But the fact of such transmissibility rests neither on embryological nor theoretical grounds. It is a fact so fully demonstrated in the history of our domestic animals and the history of agriculture, that the skepticism of some of our great naturalists and embryologists must be attributed to that ignorance of the farmers' commonest experiences which is, unfortunately, a too frequent attribute of the city-trained investigator. Darwin in the beginning, and while the importance of natural selection was growing in his mind, allowed little importance to use and disuse for the same reason that he subordinated external agencies; viz., that, in proportion as it acts on masses simultaneously, it must diminish the importance of natural selection. Yet he allowed more weight to it toward the end and has furnished some of the best evidence drawn from domestic animals of the transmission of acquired characters, affecting the dermal, muscular, osseous and nervous systems. Spencer has shown that inheritance of functional modification is most easily observed and experimentally proved in those parts which admit of easy observation and comparison, as the dermal covering and the bones; and that they for the most part are beyond these tests in the muscular and nervous systems. Yet he logically concludes:

"Considering that unquestionably the modification of structure by function is a *vera causa*, in so far as concerns the individual;

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and considering the number of facts which so competent an observer as Mr. Darwin regarded as evidence that transmission of such modifications takes place in particular cases; the hypothesis that such transmission takes place in conformity with a general law, holding of all active structures, should, I think, be regarded as at least a good working hypothesis."

So far as Entomology bears evidence, it confirms the fact that modifications of structure due to use or disuse on the part of the individual may be and are transmitted. These are easily observed in the exo-skeleton, and while the experimental proof is yet limited, it is not wanting, especially in the history of apiculture. Excessive use of any organ will develop or enlarge it at the expense of other organs, just as disuse will cause a diminution, or atrophy thereof. The variation in the individual will be within limits, but when once the variation has set in, the tendency is always to an increased variation in the same direction in the descendants, especially if they continue the same use or disuse. Here, again, however, it is difficult to separate the modification due to individual effort, or want of effort, and the more general modification affecting the mass of individuals of a species through the environment; because the environment affects function, and function in its turn affects form and structure. The life of every individual furnishes an excellent illustration of new action and new uses for organs not previously used, in the striking and sudden employment of postnatal organs, both of respiration and nourishment, which pre-natally had no corresponding action. Romanes has argued that *Cessation of Selection* may reduce an organ where use or disuse can have no play, as in the loss of wings in neuter ants; and that by the law of compensation an organ may even be increased, as in the heads of such neuters. He enforces the idea by exampling the blind crabs of our Kentucky caves, where the complex eyes rapidly disappear under cessation of selection, but where the persistence of the foot-stalks indicates that economy of nutrition could have had little play! It is difficult, however, to draw the line between this cause and Lankester's reversal of natural selection; and still more difficult to say wherein either differs from mere disuse.

Degeneration which has been urged as the true explanation of many of the existing forms of life is, it seems to me, but a consequence of disuse and would therefore fall into the present category, among causes of variation.

Emotion as affecting the Individual.—I have here considered the

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factor of use and disuse as a direct cause of variation, from the psychical rather than the physical standpoint, *i. e.*, individual or conscious effort as furnishing food for natural selection, among more highly endowed animals, rather than as effort by species as a whole necessitated by physical conditions and inducing modification in masses irrespective of selection. This leads us to the consideration of mind as a factor in evolution, and we shall soon see its importance as a fundamental cause of differentiation, among higher organisms at least. I am not sure, even, that its influence can be excluded from among lower animals, however much we may have to exclude its action in so far as plants are concerned; for any new functional effort inducing new use may be looked upon as conscious and intelligent as compared with use fixed by habit and lapsed into automatic action or instinct. The former typifies variability and progress; the latter constancy and stability.

Mind is a comprehensive cause of variation and may be considered under several categories: We have, for instance, (1) the action of the mind of the individual in willing, or in selecting between differing alternatives that present themselves, as in the choice of means to ends; (2) the direct influence of the emotions on the individual; and (3) the influence of the emotions of the pregnant mother on her offspring.

In the first category the influence of mind in modifying is chiefly confined to man. It must have acted from the time when he first began to prepare his crude weapons of defence and offence to the present day, when some new discovery or some new invention may alter the map of the world, revolutionize society, or give one race or nation the advantage over another; nor can we feel sure that animals below man have not been modified by similar psychical effort. In the second category, the direct influence of the emotions on the individual, it is a psycho-physiological factor involved in the question of use and disuse; for if it be once admitted (and I think the tendency of modern neural science is in the direction of establishing the fact) that strong mental effort may be made to affect special parts of the body, *i. e.*, that an excess of nervous force brought to play on any particular organ or any particular part of the organism, induces increased growth or development of such parts; we can understand how far desire, especially under the spur of necessity, may be influential in inducing modificatiou. Lamarck's idea, therefore, may not be so ridiculous as it has hitherto been

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supposed by many. Darwin took no stock in this influence, and referred with some contempt to the views of Lamarck, and Geoffroy-St. Hilaire. He thought it strange that the author of "Les Animaux sans Vertèbres" should have written that insects which never saw their eggs should will them to be of particular form, which he thought hardly less absurd than to believe that the desire to climb should make a Pediculus formed to climb hair, or a woodpecker to climb trees.

Emotion of Mother as affecting Offspring.—There may be some doubt about the extent of the influence of the individual mind in inducing direct modification, for the subject is a difficult one to deal with and we have few exact data to draw from. Since in human affairs we recognize the power of will in affecting purpose and action and in moulding character, it is legitimate to infer that when our knowledge has increased we shall recognize its effect on function. There can be less doubt as to the third category, viz., influence of the mind or emotions of the pregnant mother on her offspring in inducing modification both physiological and mental. As a cause of variation, though believed in by J. D. Hooker, as we learn from the "Life and Letters," and by other of Darwin's contemporaries, it was discarded by Darwin himself, his principal reasons being that the results of observations made for him in hospitals were adverse to any such influence. Medical men, as a rule, also discard it as among the mere notions and superstitions of women, and argue its impossibility on the ground that there is no neural connection between mother and fœtus. The ancients practically recognized the influence of the imagination of the mother on her offspring, and belief in it is still very prevalent among women themselves, of all classes. Women alone are able to speak or feel in this matter, from experience, and the almost universal belief in the influence, among those who have any experience at all, should make us hesitate to discard it too summarily. From facts within my own personal knowledge I have long believed in this influence, and the more I have been able to collect reliable data bearing upon it, the more confirmed have I become in the conclusion that the emotional experiences of the mother affect the issue in varying degree, according to the intensity of the emotion. When sudden and excessive as in rage, fright, repugnance, etc., or where prolonged or accumulative, as in continued brooding, it may induce nervous disorders and even mental aberration, idiocy or insanity; or, again,

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physiological change, as atrophy or increase of parts, and other peculiarities which have relation to the form or character of the inducing mental manifestation or shock in the parent. Investigation of this, as of all subtle phenomena, is attended with the difficulty of separating the chaff of fancy from the grain of reality. The method pursued by Darwin is unsatisfactory, as it dealt with normal conditions which furnish no evidence and with the fanciful or notional side of the subject. The literature of the subject is extensive and quite interesting, and I would refer particularly to the work and writings of Viellard, Schœnfeld, Demangeon, Lucas, Féré and Brown-Sequard. Two other difficulties confront the investigator: first, the somewhat unsatisfactory state of neurology and the difficulty of experimental research therein, as indicated by Vice President Bowditch before this section two years ago; *secondly*, the aversion, from feelings of delicacy, on the part of the persons concerned, to publicity of the more marked and striking evidence. The phenomena of hypnotism, proving as they do that physiological results may be induced through the imagination of the subject acted on by the mind of the hypnotizer, are suggestive in this connection, the work of Charcot in Paris more particularly showing how powerful the action may be and how the effects of actual medicines may be produced by the use of imagined ones. The mind of the hypnotized under these conditions is brought into those exceptional and exalted conditions which are necessary in the case of the mother to produce on her offspring the effect which we are discussing. The recent experiments of Mr. C. T. Hodge on the effects of stimulation on the nucleus and cell-body and on protoplasm are also interesting here showing, as they do, decrease in the two former and vacuolation of the latter as the result.

The history of science is present to tell us that common and persistent belief, based on experience, has not infrequently been met with skepticism and even ridicule on the part of scientific men, only to be vindicated finally by more thorough and exact knowledge. It is too often the case that, where the processes are recondite and difficult to follow, assumption passes for knowledge. The function of some of our own bodily organs yet remains to be established and we probably assume too much in requiring that all nervous force must be transferred through nerve tissue, or that there may not be protoplasmic filaments which are not resolvable, in their finer ramifications, even with our best microscopes. The

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very nature of mind and its processes puts it beyond the reach of the scalpel of the anatomist or the physiologist, just as many psychical phenomena baffle the exact methods of science, at least those so far employed. Leaving out of the question the evidence of peculiar marks due to maternal emotion, cases of which are part of the unwritten history of almost every family, the striking cases of which I have authoritative evidence of addition to, subtraction from, or singular modification of, anatomical parts, confirm me in the belief that this is a most important psycho-physiological cause of modification.

In the romance of Elsie Venner, in which the heroine's strange attributes are connected with pre-natal influence of the mother, who died of the bite of Crotalus, Oliver Wendell Holmes has strongly put forth this doctrine in the form of fiction. I allude to this clever romance because of the medical knowledge of the eminent author, and because while admitting in the preface that a grave scientific doctrine lies beneath some of the delineations of character, he also affirms that he has had the most startling confirmation of its truth. The data collected on the subject I hope to bring together on some other more fit occasion, and I would take this opportunity of urging any in my hearing or who may read these lines, if they have had or are aware of any authoritative and illustrative cases, to communicate them to me with as much detail as possible.

This theory once established, its bearing on evolution as a prime cause of variation must at once be manifest; for it gives not only tangibility to the Lamarckian idea of desire influencing modification, but, also, a conception of how Infinite Mind in nature may act through the finite in directing such modification. No doubt but that there is a great deal of nonsense and superstition mixed with the genuine, and that the idea that every little whim, or fancy, or imagining of the mother will produce record, or mark, is one of the unjustified outcroppings of the fundamental fact, and helps to explain the difficulty of getting at the real facts and the ease with which Darwin rejected the idea. In my judgment this factor acts only when, from whatever cause, and particularly under the spur of necessity, the emotions are exceptionally intensified, or the desire strongly centred in some particular object. The conception is perfectly legitimate, for instance, that when a species is subjected to any external modifying cause, affecting all its members alike, the adaptive modifications which natural selection, under such circum-

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stances would play upon, have their origin in the emotions, or the influences at work on the pregnant females, giving direction in their offspring, to the needed changes. In this way it is probable that only those individuals born under such conditions would be able to survive. Thus this becomes no mere ancillary cause of variation but one of deepest import and at the very foundation of evolution. The female in this light acquires an increased importance, and evolution finds her not only the essential at the dawn of life upon our planet, but, in its present highest manifestations she is nearest by instinct, intuition and aspiration to the Controlling Mind, which in the beginning quickened the great womb of nature and down through all the ages guided the continuous stream of life to designed ends through the individual womb of the mother.

As already remarked, the psychical factors which we have been considering are substantially Lamarckian, and in proportion as we consider them and get to understand the other direct causes of variation, must we give importance to the ideas of Lamarck and, conversely, less importance to the ideas of Darwin.

Did time permit I should like to go into an analysis of Lamarck's "Philosophie zoölogique" and show how the genius of this illustrious French naturalist anticipated a very large part of that which Darwin subsequently so laboriously helped to establish. I must pass the subject, however, and simply record my surprise that one who was otherwise so honest and fair toward other writers was so evidently unfair in his estimate of the work of Lamarck, as Darwin, in the "Life and Letters," is shown to have been. It is incomprehensible, reading Lamarck with our present knowledge, that Darwin should have found neither fact nor ideas in a book which abounds in both, except on the theory of a poor translation or that strange national antipathy which has so often prevented the people of one country from doing justice to those of the other, and which so long prejudiced the French Academy against Darwin's own especial theories.

Darwinism assumes essential ignorance of the causes of variation and is based on the inherent tendency thereto in the offspring. Lamarckism, on the contrary, recognizes in use and disuse, desire and the physical environment, immediate causes of variation affecting the individual and transmitted to the offspring in which it may be intensified again both by inheritance and further individual modification. Both represent important principles in evolution and

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coöperate to bring about the results. The theory I propose gives renewed importance to the Lamarckian factors by showing one manner of their action not previously urged and it also helps us to a tangible and scientific conception of design.

Acceleration and Retardation.—In this rapid glance at the immediate causes of variation we have discussed some factors which, in some degree, represent laws rather than inducing causes of variation. This difficulty appertains to all attempts at formulation of the causes of variation, and only as our actual knowledge increases shall we be able succinctly and definitely to classify the factors. There are, however, certain important laws which have influenced modification but in no sense can be looked upon as causes of variation. They are laws or principles of evolution by which we may account for the formation of types, acting, just as natural selection does, in differentiating rather than in originating the variation. No one can have followed the important and suggestive works of Cope and Hyatt on the subject of acceleration and retardation and not feel that it expresses an important law of this kind. It is, as I understand it, a factor in evolution not comparable with the principle of natural selection, but complementary thereto, much in the same way as physiological selection and sexual selection are. It is an attempt to give expression and form to a set of facts to which palæontology undoubtedly points and which ontogeny substantiates, viz., that certain types may attain perfection in time and then retrogress and finally become extinct, and that existing types which are dying out, or degenerating, exhibit, ontogenically, the culmination of force and complexity, followed by decadence, corresponding to the phylogenic history of the type. We know, from the "Life and Letters," that Darwin gave up in despair the attempt to grasp the full meaning of these particular views of our associates, and in a letter to Hyatt, with characteristic modesty, he attributes this inability to his own dulness rather than to any weakness in the theory. Others have experienced the same difficulty and believe, with Professor Morse, that the facts enumerated, as well as the facts of exact and inexact parallelism are explicable on the doctrine of natural selection. This is true, it seems to me, only on the broader, unjustified interpretation of the doctrine to which I have previously alluded in the opening of these remarks. The law of acceleration and retardation may, perhaps, be substantially stated in this wise: that certain groups acquire some charac-

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ters rapidly, while corresponding groups acquire the same characters more slowly, or never acquire them at all, and this brings us to another important factor of evolution which serves to give force to the law.

Acceleration by Primogeniture.—This has been elaborated by Hubrecht. He argues that so long as the parent form remained most in harmony with the surrounding conditions it would maintain in the struggle for existence its characteristics against all tendency to vary in its offspring; which is equivalent to saying that it will remain unchanged so long as the environment remains the same. He then shows that in organisms in which the reproductive period covers many years, accelerated development by primogeniture, *i. e.*, as between the first born and the last born of any pair and of their posterity, will, in time, produce differentiation. The series of the first born will, in the course of time, involve many generations at short distances from each other, whereas, the series of the last born will, on the contrary, consist of a much smaller number of terms each separated from its predecessor by a more considerable distance. Any tendency to variation from external or internal influences must needs find more numerous occasions to act in the series of the first born, not only because these have a more composite ancestry but because they necessarily become the most numerous. In other words, the chances are more numerous for small differences among the first born series, and in proportion as such differences are accumulated, intercrossing and bastardizing with the series of the last born will become rarer. This law will gain from physiological selection and, it seems to me, throws additional light on that of acceleration and retardation. It must act more particularly among higher animals where the reproductive period is lengthened and the time between the first and last born is great.

Saltation.—We are thus led to what have been called saltations in evolution. Although the history of palæontology has continually added to our knowledge of past forms, and helped to fill up many gaps in the evolutional series, and although, during the last quarter of a century, it has particularly vindicated Darwin's prophecy that many links would yet be found, the substantial truth remains that gaps still occur, and that progress, so far as present knowledge indicates, has been made by occasional saltations. There have been, it would seem, periods of rapid movement, and of comparative repose, or readjustment of equilibrium. Cope con-

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cludes that, "genera and higher categories have appeared in g
logic history by more or less abrupt transitions or *expression poi*
rather than by uniform gradual successions."

One of Pictet's strongest points, in opposition to Darwin's t
ory, which struck Darwin himself with much force, was that
ill agreed with the history of organisms with well marked and
fined forms, which seem to have existed during but a limited peri
as for instance, the flying reptiles, the Ichthyosaurs, Belemnit
Ammonites, etc. Some authors, who have fully recognized th
gaps or leaps in the developmental history of animals, yet belie
them to be consistent with the theory of gradual modification.
may be only one individual of many which becomes modified a
transmits the modification to descendants: it may be but one s
cies of a genus which, for similar reasons, supersedes the rest wh
become extinct in time proportioned to prolificacy.

There is no reason to suppose that the history of organic life h
differed in this respect from that of inorganic. We need not d
cuss here the question of catastrophism and uniformitarianism
geology. However much the latter prevails at the present tin
both have doubtless operated in the past. Catastrophism wou
necessarily produce gaps, or saltations, in the palæontologi
record, as only the more plastic species would adapt themselv
and survive under its influence. It is not gaps due to such caus
that are here to be considered, however, but those which occur
uniform strata. Haldeman has most suggestively remarked th
the same mineral will crystallize with three, six or twelve angl
but not with five or seven, and he asks: are the facts of orga
morphism subject to less definite laws? Cope has drawn anot
illustration from inorganic forces, in the three great changes
water, from solid, liquid and vapor, which take place suddenly
what may be called three *expression points* of the thermometer, t
many intervening degrees involving no change. Rhythm or wa
movement would seem to be a universal attribute of matter, whet
organic or inorganic. The forces of nature are constant, but t
phenomena induced are often paroxysmal. The progressive forc
accumulate, while the conservative forces resist until at last resi
ance gives way with comparative suddenness. There is every re
son to believe that the life movement, in its ascending complexit
has shared this common law. Accumulation is proportioned to t
change in environment, and resistance to the age or rigidity of t

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organism. The latter may be strong enough to end in death or extinction, or it may break down and, with comparatively sudden yielding and conformity to necessity, burst the confines, and begin a new series of variations and adaptations. In either case we have breaks, because the dying or dropping out of one type makes room for another, more accommodating. Rapid evolution, from causes already discussed, implies gaps which must be marked according as the strength of the conservative forces and the violence of the final accommodation are great, and because sudden breaks are more apt to occur after long periods of stability. The break may be induced by changes in physical environment or without such change; if the latter, it will more likely occur in some individual, born with a marked departure from the type that gives it some advantage, and whose issue will in time supplant all other individuals. In either case, we shall have, palæontologically, distinct species or genera, one superposed on the other, without links. To the imperfection of the geologic record is to be attributed, no doubt, a large number of these gaps yet existing between types, and many important links, or branches, are yet to be discovered. Yet the views we have been considering should absolve evolutionists from all necessity of demonstrating the more minute gradations; because, in deposits like the Tertiary, during which we may assume life-conditions to have remained comparatively uniform, these saltations take place. Saltation, or, what is probably a truer expression, wave-movement, would indeed seem to be a prerequisite of progress and will account for much that is going on even at the present day. In artificial selection by man we find that it is at first comparatively easy to accumulate minute peculiarities and variations by rigid breeding and exclusion of all deviation; but that we soon arrive at a fixed point which is maintained at first with difficulty but with increasing ease with each generation. During these more fixed periods the potentiality for change is doubtless increasing, until at last it is suddenly manifested in renewed variation. Rest is followed by activity just as surely as activity induces and requires rest.

There is a limit to development in organs, just as there is a limit to individual mental growth. Weariness of previous effort comes upon us when the limit of result is attained, accompanied by great longing for change and not infrequently with revulsion from previous effort. The naturalist who has devoted a part of his life to

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the persistent accumulation of facts and specimens, has held the imaginative and generalizing powers in abeyance during that period. The reserve brain force in this direction may be suddenly called into activity by exhaustion in the other, and the process may perhaps be comparable to the exhaustion of the soil for one particular crop, without lessening its fertility for some other, the recognition of which fact is the foundation of all successful agriculture. Excess of development, whether in body or mind, inevitably brings about either wholesome reaction or utter collapse.

How far the rhythmic tendency in the development of animal life may be explained by the rapid change of climate, by migration and the loss of record, or upon the general law that while there has been progress of the whole, there has not necessarily been progress of every part, it would take us too far to discuss in this connection. I think we are safe in saying, however, that the facts justify belief that, in the evolution of animal life, as in the evolution of everything else, progress has often been made by waves.

The Fiskean Law.—With regard to what may be called the Fiskean law of correlation between brain development and infantile dependency, Fiske has so admirably elaborated the subject that it needs no further elucidation here as the principal factor in the evolution in man, first, of the family relation, then of the clan, the tribe and the nation. With this factor in mind, and the immense superiority which anthropoid man must have had, when brain development had once induced this fundamental community of interest, over the rest of brute creation, the gap between primitive man and the higher anthropoid apes in the past or between the present lower races of man and the higher existing primates is easily explained, even if it had not been greatly exaggerated. At the present time we may note and record the further inevitable increase in the gap, for the lower races of man are gradually becoming extinct and the higher apes cannot long hold their own or persist.

The Brooksian Hypothesis.—I have already alluded to Brooks's hypothesis under the head of sexual differentiation, and his work on Heredity must be so familiar to you that his views need but a passing notice. He believes that sex differentiation means fundamentally a physiological division of labor and that the male is essentially the progressive or diversifying and the female the conservative agent. As organisms gradually increased in size, as the number of cells in their bodies became greater, and as the differ-

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entiation and specialization of these cells became more and more marked, one element, the male cell, became adapted for storing up gemmules and, at the same time, gradually lost its unnecessary and useless power to transmit hereditary characteristics.

The theory finds support in some of the phenomena of life and doubtless expresses a law not easily established, for which reason it will not be readily accepted. It leaves entirely out of consideration some of the forces at work which I have already indicated and in so far must be considered only a law of secondary importance. However much we may admit the general truth that the germ cell continues the past and the sperm cell tends to diverge from it, as a purely dynamic proposition, inducing variation for natural selection to play upon, it does not in any way decrease the overwhelming importance of the female in inducing, through psychico-physiological influences, a needed and purposeful modification in the manner which I have already expounded.

Having thus considered some of the proximate causes of variation and some of the more general laws of evolution we are naturally led, in conclusion, to consideration of original or Infinite Cause. Far be it from me to try your patience with any prolonged speculation upon the more profound problems of life and of futurity which have been dealt with by able men of all times and with such conflicting and varying results. I shall content myself, in closing, with a few words upon those themes which, as biologists, we cannot ignore, and to which the subjects we have been considering inevitably lead.

Mind, as exhibited in organic evolution, however simple or complex may be its manifestations, is, in essence, one and the same force. There is an undoubted gradation from simple sensitiveness and volition, to the more complex instinctive and reasoning faculties of higher animals. The concensus of opinion of biologists who have given the subject any serious consideration is that animals exhibit all our mental endowments in degree. They possess desire, affections, imagination, memory, comparison, judgment, and all the other attributes of human intellect, more or less perfectly developed, and there should be no more doubt of the gradual evolution of man's intellect from preëxisting lower and simple forms of aggregate mind, than there is in the derivation of his more complex and powerful brain (the medium of mind) from smaller and simpler brains, or of his body from simpler, less specialized forms.

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Some of our profounder thinkers feel that all the phenomena o
the universe are but forms of motion, and that the great final an
creative force may best be imagined as the centre and the sourc
of motion. In this light, it is, perhaps, not too much of an exag
geration to conceding to plants a certain amount of mind, and i
establishing the fact of universal movement in plants; in showin
that circumnutation is an inherent quality or manifestation of plan
life, Darwin may well be said, as Professor Ward has expressed i
"to have gotten at the final cause of all evolution." Indeed,
must be difficult for a botanist, considering that all the terminal
of a plant, whether beneath or above the ground, are constantl
feeling and choosing; or when he reflects on the wonderful motion
and *selecting* power of climbing plants, but more particularly o
the strange phenomena exhibited by insectivorous and entomopl
ilous plants; it must be difficult for him, I say, to relegate to th
limbo of the unconscious, the whole of his pet kingdom. In hi
letters, especially to Hooker, Darwin says, speaking of the circum
nutation of *Echinocystis lobata*: "The tendrils have some sense, fo
they do not grasp each other when young," and again of the move
ments caused by light, gravitation, etc., he says: "It has alway
pleased me to exalt plants in the scale of organized beings, and
have therefore felt an additional pleasure in showing how many
and what well adapted movements the tip of a root possesses." I
studying the movement of flowers, especially in their sexual rels
tions, I have often felt, with the poet that:

> "'Tis my faith,
> That every flower enjoys the air it breathes"

and that, however much conscious sensation may have lapsed i
most of their manifestations of growth, sensation may still be con
scious, and mind still work, in dim fashion, during the season o
reproduction, in the specialized and reproductive parts. It ma
be a fancy, but who can prove it unjustified?

Where, then, shall we draw the line in the evolution of mind be
tween the high degrees of consciousness in animals and self-con
sciousness which is believed to be a peculiarly human attribute an
at the foundation of all that constitutes con-science and makes hi
a moral and responsible being? The beginnings of self-conscious
ness are traceable in animals, since many of the phenomena o
sexual selection and the well known sense of shame in our domes

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tic associates could scarcely have resulted without it, and it seems to me illogical to argue, as some of our best writers on evolution have done, that self-consciousness is an attribute that must have been breathed into man by special, supernatural act.

From the consideration of the general subject of mind in nature, we are brought inevitably to the question of Design. There can be no doubt that the tendency of evolution has been to remove further and further the idea of an Infinite First Cause, and pure Darwinism exhibits to us a cold and cruel world,—exemplifying the Hobbesian theory of self-love, nothing having any reason for existence except its own welfare. It leaves out all the higher beatitudes of nature, the higher aspirations of men, and all those internal yearnings or laws of internal growth and influence, not for the individual alone, but for the good of the whole. Natural selection, while not disproving Design, pushes back the argument and limits it to the order of nature as a whole, since much of the modification and adaptation is accounted for by known and recognized physical conditions. The argument for design, however, as Asa Gray has so well set forth, rests on the fact that the designed and the contingent can never be accurately discriminated and that limitation, in the very nature of the case, is inconceivable. There are those who see only in nature the inevitable and necessary manifestation of the forces of the universe, and assume them to have been without beginning and to be without end. There are others who find in the unity—the oneness—of the forces of nature full evidence of Design. So far as logical inquiry will aid us, the recent controversy between Messrs. Cope and Montgomery may be cited as typical of that which has always separated the two schools, and sufficiently shows how opposite conclusions may be reached by those equally able and equally conversant with the evidence. The former contends that mind exists independent of matter, or, to use his own words, "primitive consciousness exists in primitive forms of matter and constitutes a primitive person, or Deity;" while the latter maintains that the mind of living beings is, itself, only a product, or outcome of their organization.

Darwin, as is evident from the "Life and Letters," was induced by his life-work gradually to abandon the rigid tenets of the Christian church, and to substitute therefor a more latitudinarian form of belief. He was content to limit his investigations to truly scientific methods, realizing fully that all speculation in reference to the

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great First Cause involves the discussion of the supernatural whicl is necessarily beyond the natural. The discussion of these ques tions can be very little affected by the methods of natural scienc and the more thoroughly we recognize this fact the better it wil be for both religion and science. It ill becomes us to be dogmati in questions beyond the limits of induction, or where the mind at tempts to fathom by deduction and speculation. Natural scienc necessarily deals with natural causation.

A few expressions from the "Life and Letters" may he quote here. Darwin says: "The old argument of design in nature, as give by Paley, fails now that the law of natural selection has been dis covered. We can no longer argue, for instance, that the beautifu hinge of a bivalve must have been made by an intelligent being like the hinge of a door by man. There can be no more design i the variability of organic beings and in the action of natural selec tion, than in the course the wind blows." He asks whether we ar to believe that organic forms in nature are preordained. If so why should we not believe that the variations of domestic animal and plants have been preordained for the sake of the breeder; ye if we give up the principle in the one case we must do so in th other. Again: "No shadow of reason can be assigned for the be lief that variations in nature have not been the result of the sam general laws which have formed the groundwork, through natura selection, for the formation of the most perfectly adapted animal in the world, man included, without intentional or specific guide." Yet, while he was willing to remain an agnostic, feeling that th beginning is insoluble by us, he gave some of the most cogent rea sons, aside from the feelings and emotions, for the belief in the ex istence of a First Cause—of a God. In his correspondence wit Gray, he shows how he cannot bring himself to believe that beneficent and omnipotent God could have designed the charac teristics of parasitic and carnivorous creatures, with all the othe heartless manifestations in nature. Yet he was not content, in com templating the nature of man, with the idea that everything is th result of blind force. He believed in design with the details, whethe for good or bad, left to the working of what, for want of a bette term, we call chance. With the utmost candor, he confessed that thi view was not at all satisfactory to him, but that the whole subject was too profound for the human mind, likening our speculations upon it to those of a dog on the mind of Newton, and believing

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that each man should hope and believe what he could. Again, in a letter to Lyell, June 4, 1860, he remarks, "As squared stones, bricks or timber are indispensable materials for a building and influence its character, so is variability indispensable in influencing selection;" and that, "in the same manner as an architect is the all-important person in the building, so is selection with organic bodies." The parallel is evidently weak here and we may well insist that from Darwin's own statement, the idea of an intelligent architect or designer in the one case is as all-important as in the other. The same is true to some extent of the argument from artificial selection, or the manner in which *intelligent* action in man acts on domestic or cultivated organisms. This is not limited to the mere choosing of chance variation in beneficial directions, but involves also purposeful feeding, training and treatment, to induce the desired amelioration and variation. Just as the production of new forms among domestic animals or cultivated plants implies a purpose—a designer; so may the origination of such forms in Nature imply intelligent design. Both Lyell and Gray believed in the form of variation having been planned or designed. It seems to me that the evidences of design in nature are so overwhelming that its advocates have an immense advantage over those who would discard it. A fortuitous cosmos is, to most persons, utterly inconceivable; yet there is no other alternative than a designed cosmos. To accomplish anything by a process, or by an instrument, argues greater, not less power, than to do it directly, and even if we knew to-day all the causes of variation, and understood more thoroughly than we do the method of evolution, we should only carry the sequence of causes a step farther back and get no nearer to the Infinite or Original Cause.

The most philosophic view is, probably, that which, while recognizing an intelligent creative power, or mind, which has worked and is yet working through ordained laws, yet leaves the detailed manifestations to secondary causes and finite action. Limiting conditions, or laws, since law is but a limiting condition and nature an active power, may act together in producing secondary causes but the great and Infinite Cause may be looked upon as that which upholds the universe.

The tendency of those who would advance theological conceptions from evolutional grounds is doubtless to some monotheistic form,

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or a sort of psychical pantheism, which sees the Infinite immanen in Nature — an all-pervading, interpenetrating Essence. This i the All-conscious, and I know of no better intellectual conceptio of immortality than resolution of the finite individual life and con science into the All-life, All-conscious—a conception justified an affirmed as it is by evolution. But the one great point which I wis to emphasize in alluding to these differing views is, that, beyon the limits of the scientific method, speculation becomes *faith* an the most profound writers are obliged to use the simple *I believ* which most theologians begin with. The sentiments which const tute true religion — the sense of impenetrable mystery and mora obligation; the higher humanitarian promptings and hope of fu ture life,— are apart from science and cannot, therefore, be affecte injuriously by its methods.

Evolution logically involves the idea of the origination of lif from the inorganic forces at work on our globe and only in thi sense does it modify our conception of the Creator. The one vivi fying force in nature must needs be an endless source of power an movement, with the potency of all that is in what we call universe Art and plan being manifest therein the power must needs be in telligent, and we can compare it with nothing more satisfactoril than with our own conscious thinking power, whether we call i soul, spirit, the Absolute, the Infinite, the Unconditioned, the Un knowable, the Creator, the Divine Mind, the Supreme Will, God, o by what other *nominis umbra* we choose to express the conception

And now, Ladies and Gentlemen, wisdom admonishes me to b brief. I have ventured just within the question of design becaus of the prevalent belief that evolution eliminates it from our con ception, and because I have felt that as between the extreme school the middle ground chosen by our late lamented Gray, is far th more satisfactory and philosophical. On the other great questio of what life is, or how it originated, I commend the candor of Mars in closing his address as president of the Association in 1877 wit the words "In this long history of life, I have said nothing of wha life is. And for the best of reasons, because I know nothing."

If we endeavor to formulate the idea of life we shall not lac for excellent guidance in past utterances of those who have bee and who are yet members of this section of the Association. I fact we may well feel proud to live in the generation which has pro

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duced some of the ablest experimenters whose work will have enduring influence in bringing us nearer to a true comprehension of the forces under which we live. Professor Barker, in his presidential address for 1880, on "Some modern aspects of the life question," seemed to some of us on the verge of chemically and physically explaining and defining the thing itself; and, yet, though we seemed, while listening, to near the gates which opened the secret we got but a glimpse into the great mystery. It matters very little whether we follow the great writers who have wrestled with this question in the past, or those who have been or are still with us, we must acknowledge our utter incapacity to comprehend the most patent phenomena of our being. We try in vain to analyze life; we try equally in vain to measure thought.

A little transparent colorless material christened protoplasm is believed to be the physical basis of life and the seat of all those marvellous powers and properties belonging thereto. We may trace back from death and dissolution the individual life to its very genesis in the organized cell, or ovum; we may go farther back, and trace it to the unorganized nitrogenous hydro-carbon compound which has been named protoplasm; but we yet fail to apprehend the cause of its vital functions, of its powers of assimilation, irritability and reproduction—the potentiality of the living as compared with the dead stuff. So in the past history of the type, we are led back to the same mystery. Ontogeny and phylogeny alike lead us to the riddle of the beginning of life. Huxley may well say that the process of development of the egg, like that of the seed, is neither more nor less mysterious than that by virtue of which the molecules of water, at the freezing point, build themselves into regular crystals. In either case it must be very largely a question of temperature. But while in the case of water the effect is at a fixed degree, in the case of organic life the degree is variable. We may say, with one of our most profound and respected writers, that organic compounds are "substances whose highly complex and very unstable molecules are composed themselves of inorganic compounds or of organic compounds of lower organization formed on the cool surface of fully developed plants at life-supporting temperatures." We may assume that increasing complexity and instability of nitrogenous substances give us proteids and finally protoplasm. We may find that the forces upon which the movements and changes

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of this substance depend are the very same which determine those of a drop of water or a bit of mucilage; that all its movements are referable to the mechanics of molecules as exhibited in liquids. But the fact remains that the physicists who help us to a better understanding of the material properties and processes of protoplasm are only dealing with the methods and no more solving the great mystery of life than did Darwin or any of the other workers who have helped us better to comprehend its processes.

It was my privilege in years gone by to meet frequently with a little coterie of metaphysicians in St. Louis which included men like Wm. T. Harris and Thos. Davidson, who have acquired national reputation. With strong inductive tendency of mind I was all the more anxious to follow their erudite discussions of the philosophies of Aristotle, Kant and Hegel, but was too often overwhelmed with the feeling that my friends were dealing in mere words and that philologic juggling too often passed for reason. May we not truly say the same of those biologists who endeavor to give us a purely physical or materialistic explanation of life? I have certainly sometimes felt, in following their writings, that we scarcely get away from the thraldom of mere words. I felt this strongly, again, while listening to the symposium by a number of our greatest authorities (Schäfer, Lankester, Krause, H. M. Ward, Carnoy, Hartog, Gardner and Sedgwick) on the present aspects of the cell question at the meeting of our sister society in Manchester last autumn; for if there was one result which clearly came out of the discussion it was that protoplasm is not a mere chemical substance but a complex structure. Yet what stupendous import has been given to it in biologic literature, since Von Mohl first used it to indicate the slimy substance within the vegetal cell and Huxley aggrandized it as the "physical basis of life." Neither it, nor Lankester's plasmogen, nor Weismann's idioplasm, nor Coues's transcendental biogen, helps to any more real conception of life itself than does Hinrichs's pantogen which he calls the "primary chemical principle or the element of elements," and upon which he bases his theory of ato-mechanics.

The genesis or formation of individual life, in spite of saint and sage, is yet a mystery and probably always will be, and the exact site of the origin of the reproductive cells, according to one of our best authorities (Allen Thompson), is even a matter of doubt.

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"Hunt as we will all matter to the end,
Life flits before it: last as first we find
Naught but dead structure and the dust of fact;
The infinite gap we cannot apprehend,
The somewhat that is life—the informing mind."

All that evolution recognizes is the transmutability—the generic identity—of the forces of Nature, which, in their aggregate action, may properly be defined as omnipresent energy. We know, as a matter of the simplest observation, that this combined force, or energy, is essential to the continuance of life, not only upon our planet, but, deductively, in the universe. We are justified in inferring that it is capable, under fit conditions, of originating life, from what we know as non-living matter. Evolution, in fact, inevitably leads to the inference that vital force is transmutable into, and derivable from, physical and chemical force. It implies, and necessarily implies, abiogenesis, either now or at some remote period in the history of our earth; and notwithstanding experimentation and advance in our knowledge of micro-organisms overwhelmingly refute Bastian's conclusions, or the idea of the present origination of organic from inorganic matter, so far as forms within our ken are concerned, yet it seems to me perfectly logical to infer a world of beings which our strongest instruments fail to reveal to us, among which abiogenesis is possible to-day or archebiogenesis was in the past, just as the molecule is a necessary physical conception though it may never be revealed to us.

It may be true that phylogeny postulates the derivation of all forms of life from a similar simple cell and that, to use Joseph LeConte's language, "the fundamental law of embryology teaches us that the history of the phylogenetic evolution of organisms is mirrored in miniature in the ontogenetic development of each individual;" but in ontogeny the simple cell from which the individual starts has a potentiality, a something which makes it different from another and it does not help us much to have this something called the *memory of the plastidules*.

We have thus been led, while considering the causes of evolution, to the conviction that they are in the end referable to an Infinite First Cause and that evolution in nowise dispels the idea of a Creator, or need in any way affect religious sentiment; for, while it destroys much of the folly and superstition that belong to the ideas

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which grew out of the false notions of cosmogony prevalent in
early infancy of the race, it points to higher and nobler form
religion and to a better code of morals. Religion is born of
"delirious yet divine desire to know," and largely grows ou
unexplained phenomena. Evolution is a principle which to-
pervades and rules the whole realm of philosophy. It establis
a noble conception of Divine nature, and exhibits God in his wo
No longer "one touch of Nature" but, essentially, "Evolutio
"makes the whole world kin." It is a bond that holds all life
gether. It shows us man as a part of the life everywhere ab
him, and promises advantage to him in more intimate knowle
of that life from which he used to think himself entirely seve
by Supreme will.

Evolution teaches that nothing is yet so perfect but it may
improved; that good comes of the struggle with evil and the
can never be dissociated from the other. The erect position wh
has given man his intellectual preëminence, has brought him m
ifold bodily ills. No evolutional sibyl looks to a milenni
Higher development must ever mean struggle. Evolution sh
that man is governed by the same laws as other animals. Envi
ment has induced some of his most marked race characters,
individual variation is greater in him than in most creatures,
this is his surest promise of betterment. The dime-museum is
quent of the fact that were any bodily variation useful, from
elastic skin to a hundred and one abnormal qualities, selec
would have no end of variation to choose from. Differentiation
gone on and is going on to make him the most heterogeneou
function, whether of brain or muscle, of all species. The di
ence between the hand of a Josef Hofmann and of the average pl
man is one which involves a large number of correlated differe
and is functionally, if not structurally, greater than that betw
the non-opposability of man's great toe and its opposability in
higher apes—a difference which has been so much made of
which finds its gradations in eastern peoples who use their toe
"handling" tools.

Evolution is particularly promising to us as a people.

> "The spirit grows with its allotted spaces;
> The mind is narrowed in a narrow sphere."

The diversified environment and the commingling of so m

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nationalities have stimulated variation and progress, making us already foremost in invention and material growth. The distinctive American type, not yet fixed but forming rapidly, must profoundly influence man's future on the globe, and evolution teaches that by so far as the contest is severe with those forces which are disintegrating and destructive to liberty will the final improvement be greater. The effort and advancement of to-day, in all directions, will form the inheritance of future generations.

But the struggle for existence in civilized man is no longer one solely for physical adaptation to natural environment or physical supremacy, but is one rather of ideas and purposes. It goes on in an environment of intellect and morals.

In addresses before this Association, Professor Morse has eloquently alluded to some of the more practical teachings of evolution as they should (and in the future doubtless will) affect governmental and political action. The higher forms of human law and order acquire meaning when we realize that crime is largely the persistence of ancestral traits, and that our laws are best when best suited to eliminate these barbarous propensities from the race. We can scarcely do our duty even to the criminal without a due comprehension of the power of heredity to jump back to an ancestral copy even in minutest detail.

The old forms of theology have encouraged a species of parasitism by denouncing man, as a whole, as condemned to eternal damnation—as inherently wicked by inheritance—and by offering him salvation through the help of others. Evolution teaches the care and preservation of the body and not its sacrifice; it teaches that right-living and right-doing ennoble; that inactivity, parasitism, viciousness of every kind, are degenerative forces in bringing disease and suffering and retribution. It shows that the worst ills are part of a legacy which no court admits to probate, but which nature executes relentlessly. It teaches the importance of proper environment and influence, especially in childhood, in order to improve what we may inherit for good, and counteract what we may inherit for bad. It shows the necessity of establishing the habit of right-doing and right-thinking where the old systems neglected both body and mind and relied on preaching and punishment. It teaches that our moral and penal codes should be so framed as to prevent the propagation of diseased and vitiate constitutions. It teaches that every increasing advance follows use and effort, while

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degeneracy follows disuse and stagnancy. It teaches that man has risen from a lower, not fallen from a higher state; that from simple social conditions complex ethical conditions have resulted. It teaches that no work is complete and posits of man unlimited advancement in the future; for every advance in knowledge and every new application of science increase his moral power.

Ecclesiasticism lands the naturalist in skepticism and doubt of all that has been taught him as to the past and the future. Evolution reveals a past which disarms doubt and leaves the future open with promise—unceasing purpose—progress from lower to higher. It promises higher and higher intellectual and ethical attainment, both for the individual and the race. It shows the power of God in what is universal, not in the specific; in the laws of nature, not in departure from them. It may lead to some modification, as compared with Judaism, of the ideas of the future as it has of the past; for if the possession of the higher attributes which we denominate by the term Soul is the best promise of immortality, I believe there are many dumb creatures who are surer of it than many human brutes. All the word-moulding; all the rhetoric; all the sophistry, of those who, cradled in Mosaic theology but graduated in evolution, attempt to frame from the teachings of this last a post-mundane heaven of unalloyed joy for man alone, must in my judgment, come to naught. Their efforts remind me of the reconcilers whose business is, as Huxley has so well put it, "to mix the black of dogma and the white of science into the neutral tint of what they call liberal theology." Let us not deceive ourselves! What we accept as to the resurrection of the individual is based on other evidence than that of evolution, and is mainly a matter of *Faith*, and when it comes to forms of Faith, those are best which best subserve the moral and intellectual growth and development of society and which at the same time bring comfort and hope to the individual. The few great beliefs which have controlled the religious sentiment of the world have all helped to those ends and have been good in their day and clime. The teachings of Christ, in their simpler and purer inspiration, and freed of the narrowing incrustations of schism and dogma, transcend them all, and are, in fact, an evolution from them. Our faiths will vary as they have varied. Those who have attained to altruism may find sufficient joy and reward in present existence with its love and duty and conscious self-development, and rest

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satisfied to leave to destiny the future after death; to candidly avow them ignorant of it —agnostics. Others may feel no regret in the conviction that there is no continuity of state but only of being; that eternal unconsciousness—eternal rest—awaits the close of individual life. But we should not forget that the mass of mankind are incapable of like unconcern, and that a Faith to them is precious and even necessary. Nor should we forget that the evolution which we, as individuals, have undergone, with all its risks and dangers, awaits every new individual born. The child up to a certain age, and the mass of mankind at maturity are, in apprehension, only as our savage ancestors, and must be taught the truth according to their light. The experience gained by those who have reached the highest ethical and intellectual growth must be formulated in precept and principle to be of any benefit to society at large, and the higher ethical sentiment and religious belief—faith, love, hope, charity—are priceless beyond all that exact science can give it.

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PAPERS READ.

DISCOVERY OF THE PRODUCTION OF IMMUNITY FROM CONTAGIOUS DISEASES BY CHEMICAL SUBSTANCES FORMED DURING BACTERIAL MULTIPLICATION.

By Dr. D. E. SALMON, U. S. Agricultural Department, Washington.

AT the meeting of this Association held in Buffalo in August, 1886, I had the honor to read before the Biological section a paper entitled, "Immunity from Contagious Diseases produced by products of Bacterial Multiplication," and a second paper on "The Theory of Immunity from Contagious Diseases." In the first of these papers I gave a detailed statement of nine different experiments in which forty-five pigeons were used. The results of these experiments demonstrated incontestably that these birds, which were susceptible to the dose of $\frac{1}{2}$cc. of hog cholera virus, might be made immune from this dose by hypodermic injections of sterilized culture liquid in which the germ of this disease had been previously allowed to multiply.

Nearly a year and a half after the reading of this paper (Dec. 25, 1887), MM. Roux and Chamberland, of Pasteur's Laboratory, published a paper in the *Annales De L'Institut Pasteur* in which they gave experiments to show that guinea pigs may be made immune from the effects of the *vibrion septique* by inoculation with sterilized culture liquids in which this germ had been allowed to multiply previous to sterilization. In a footnote to this paper they say, "At the moment of going to press we read in the Annual Report of the United States Department of Agriculture, that M. Salmon has succeeded in giving immunity to pigeons from hog cholera by injecting into these animals sterilized cultures of the microbe of this disease."

In an article in the *Annales De L'Institut Pasteur* of February 25, 1888, Roux publishes another article showing that guinea pigs may be made immune against the virus of symptomatic anthrax by injections of cultures in which had been grown the *bacterium chauvœi*, which cultures had afterwards been sterilized by heat. In the same number of this periodical MM. Chantemesse and Widal publish an article on "Immunity against the Virus of Typhoid Fever by soluble substances." In this article they make the following statement: "In 1886 Salmon rendered pigeons refractory to hog cholera by inoculating with sterilized cultures of the microbe of this disease The experiment was of little weight [*était peu concluante*] because the pigeon is endowed with a feeble receptivity for this virus and because the process of vaccination applied to pigs and other mammals completely failed. . . There was wanting an incontestable experiment which showed immunity given to an animal species very sensitive to the virus by means of soluble

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substances secreted by this virus. This experiment and this demonstration are found in a memoir that MM. Roux and Chamberland published in the month of December in the *Annals De L' Institut Pasteur* on the 'Immunity against Septicæmia.' This work inaugurates a new era in bacteriology."

Hueppe in an article in the *Fortschritte der Medecin*, for April 15, 1888, takes up the history of the investigations of this subject properly giving credit to my experiments, the first of which were reported conjointly with Dr. Smith before the Biological Society of Washington in February, 1886. He shows that the objection of Chantemesse and Widal is without foundation, because of the check animals used in our experiments.

There is still a determined effort being made, however, by the assistants of Pasteur to secure the credit of this discovery for the Pasteur laboratory. In a review of my investigations of hog cholera written by Duclaux and published in the *Annales De L' Institut Pasteur* for July 25, 1888, the subject is again taken up and a labored effort made to show that my experiments were not conclusive. M. Duclaux begins his review by saying: "The works of M. Salmon on hog cholera are scarcely known in France and appear to be known little better to the European public. There are two reasons for this. The first is, that they have been published in an official report not found in commerce, and the copies which reach Europe generally go to be buried in the tomb of the ministerial archives,or in the grand mausoleums hostile to visitors that we name, in France, public libraries. The other reason, more personal to the author, is that he proceeds too much by that method of exposition which consists in pouring on the head of the reader the entire contents of his notes of researches, leaving him to make his choice among the materials which thus reach him without order and without measure. . . . . As I said in the beginning, they are not known in Europe where they scarcely figure in the journals until after the tardy communication which was made in 1887 by MM. Salmon and Smith to the Washington congress. But had they been known sooner, they would not have been sufficient to rally the then hesitating opinion on the subject of vaccination by soluble substances. They exposed the flank too much to very legitimate objections."

Before considering the objection raised by Duclaux to the experiments themselves, I desire to call the attention of the association to certain publications in which these experiments were referred to at considerable length prior to the meeting of the International Medical Congress at Washington. The first communication was read before the Biological Society of Washington, Feb. 20, 1886, and printed in volume III of the Proceedings. This paper was printed in full in the American Veterinary Review for May, 1886, and it was referred to at considerable length in an editorial printed in the New York Medical Journal of March 6, 1886. This paper contained our first experiments with sterilized culture liquids and in it was given the demonstration of the principle, that immunity may be produced by the injection of soluble substances which result from the growth of pathogenic bacteria. The paper was confined to one topic, was concisely written and occupied less than five pages, and consequently is hardly

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open to the criticism of M. Duclaux. The paper read before the American Association for the Advancement of Science in August, 1886, was printed in full in the Proceedings for that year, p. 258, and was also printed in the Medical News of September 18, 1886. It appears to me therefore that if the scientists connected with M. Pasteur's laboratory were ignorant of these investigations until after the meeting of the International Medical Congress in September, 1887, it is not because the literature was inaccessible.

MM. Chantemesse and Widal take exceptions to my experiments because pigeons, which were the animals used, were but slightly susceptible to the virus, and because this process of vaccination applied to hogs and other mammals had completely failed. It is somewhat amusing to find in the same number of the *Annales* a communication from M. Roux, of M. Pasteur's laboratory, claiming to demonstrate that immunity can be produced from *Charbon Symptomatique* with soluble substances and in which the investigation was made by experiments with animals even more insusceptible to this virus than were pigeons to the virus of hog cholera. Roux used guinea pigs, and he tells us that "cattle and sheep are the animals that most easily take the *Charbon Bactérien* the guinea pig shows more resistance to this disease; it does not always die as the result of inoculation made with the pulp of the charbonous tumor. MM. Arloing, Cornevin and Thomas have made known a mode of inoculation which always produces death to guinea pigs. To obtain this result it is sufficient to mix the virus with a solution containing twenty per cent of lactic acid. With this means of proof there need be no fear of a failure of the inoculations or of seeing the control guinea pigs resist them."

It is a rather peculiar idea to advance that we must receive without question experiments made in Pasteur's laboratory with animals so insusceptible that a foreign substance must be added to the virus in order to produce positive results, while exactly similar experiments must be rejected, when made in this country with virus, to which it is not necessary to add any foreign substance, and which, under the conditions mentioned, never failed to produce positive results. This objection was apparently disposed of by Hueppe, however, when he called attention to the control experiments and the positive results of these inoculations.

The question is, however, apparently deemed of too much importance to Pasteur's laboratory to be allowed to rest here. In Duclaux' review a new objection is relied upon to show that my experiments were valueless. It is that the liquids were sterilized at a temperature too near to the limit at which the microbe is destroyed. Duclaux claims that testing this liquid by adding a few drops to a fresh culture tube, in order to learn whether there are any living organisms present, proves nothing. "It was known," he goes on to say, "and it is still better known now, that microbes which are present in a culture are not identical, and that they have different powers of resistance to external agents. These powers of resistance are not identical, although approaching each other closely, and the more closely, the more homogeneous the culture. Nothing proved then and nothing proves yet, that all of the microbes were killed at this temperature limit of 58°–60°."

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These objections were anticipated when our experiments were planne
and anyone who will go carefully into the details of these experiments w
see that the objections do not hold good. It is true that the temperatu
of 58°–60°, at which we sterilized our culture liquids, is rather near to t
limit which is necessary to destroy all life in these cultures. While a
mitting that there may be different degrees of resistance with this ger
however, we demonstrated that 58° maintained for ten minutes was su
cient to destroy those germs with the greatest powers of resistance, becau
none were left capable of multiplying after they had been so treated. In o
experiments on immunity, we do not limit the cultures to a temperature
58° for ten minutes; on the contrary, we increased the temperature one
two degrees and we maintained this increased temperature for two hou
— in other words for twelve times as long as had been found necessary
destroy all living germs. It will also be seen by reference to the details
our experiments that, in some of these, the culture liquids employed we
concentrated over a waterbath. In these experiments the culture liqui
were heated to a temperature of nearly 100° for from one to two hours. Th
is far beyond the point where there could be any doubt of the germs bei
completely destroyed. While some of the experiments in which this eva
orated virus was used were successful, we recognized the fact, apparent
confirmed by the French investigations, that such a temperature weaken
the power of the liquid for the production of immunity. We conside
therefore, that this objection of Roux is absolutely untenable and that the
can be no question that the virus was completely sterilized in our expe
ments.

As another reason for his belief, Roux cites the small quantity of ste
ilized culture which was sufficient to produce immunity. "Thus," he say
"in the first of these experiments published in the Report of 1885, a do
of $\frac{5}{10}$ cc. of vaccinal culture sufficed to confer almost complete immuni
on a pigeon. This dose differs greatly from that which is necessary to co
fer immunity in other diseases." Roux evidently errs in this statemen
By referring to the Report of 1885 it will be found that one pigeon r
ceived $\frac{8}{10}$ cc., and when inoculated with strong virus died in forty-eig
hours, *i. e.*, this bird had no immunity whatever. Another one receiv
1.5 cc., and when inoculated with active virus was so affected that it lo
the use of its legs although it survived the inoculation. In this case the
was evidently a partial immunity. All of the other birds referred to in th
Report received over 3 cc. In our subsequent experiments we found th
2 cc. would generally confer immunity on pigeons, although in many e
periments we used 3 to 4 cc.

When we turn to the experiments made in Pasteur's laboratory, we fi
that this quantity is not so different from what was used there as we wou
be led to believe from the remarks quoted. For instance, while in the e
periments of Roux and Chamberland, for producing immunity in guin
pigs against the *Vibrion septique*, they used 120 cc. of culture liquid whi
had been heated to 105°–110°. They succeeded in producing equal immuni
with doses of only 1 cc. of the serum from the muscles and cellular tissu
which was sterilized by filtration instead of by heat. It would appe

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that the high temperature which they used for sterilizing their culture liquids destroyed to a certain extent the activity of the substance which produced immunity, just as in our experiments a still lower temperature had such an effect. If doses of 1 cc. of filtered serum repeated seven or eight times are sufficient to produce immunity in an animal of the size of a guinea pig, which weighs from 400 to 500 grammes, it is not surprising that an equal dose of sterilized culture liquid repeated twice should be sufficient to produce immunity in a pigeon which only weighs from 200 to 250 grammes. Roux also succeeded in producing immunity in guinea pigs against symptomatic charbon by doses of 1 cc. of filtered serum repeated from ten to twelve times. With these experiments before him we are surprised that Duclaux should raise this objection as to the size of the doses of sterilized culture used in our experiments.

The final objection raised by Duclaux is that this method of vaccination had failed with the more susceptible animal species; that it succeeded only with the pigeon, a species on the marginal line of immunity, and that this mode of vaccination succeeded better in winter than in summer, and that even in winter there are some failures. It is true that our experiments failed with large animals like pigs, which are more susceptible to the disease, but this has no bearing on the demonstration of the principle. With these large animals, and especially in this disease, there are other difficulties to be overcome. The large size of the animal requires a great increase in the amount of the material used, an amount for the determination of which, sufficient experiments have not been made. Again the manner in which the virus is introduced into the body under natural conditions has a very important influence. Indeed it is doubtful if the immunity of pigs can be artificially raised to such a degree as to prevent the multiplication of the germs on the mucous surface and within the walls of the intestines and the formation of those large ulcers which are characteristic of the malady and are usually fatal. It is not to be forgotten that M. Roux has not published any experiments in which he has succeeded by this method in conferring immunity on cattle or sheep against symptomatic anthrax; but I have not heard of this being urged as an objection to the conclusions from the experiments on immunity with guinea pigs which he has published.

Duclaux is wrong in supposing that our experiments only succeeded with pigeons in winter. We did not make this statement. Pigeons are more susceptible to the virus of hog cholera in winter than in summer; consequently we selected winter for the experiments because at that time our control experiments with unprotected birds were successful. It is true that some of our experiments failed, but I imagine no principle has been worked out experimentally in which all the experiments from the beginning were successful. It was necessary for us to determine experimentally the dose which was to be given to produce immunity and the number of times it was necessary to repeat the dose. We also endeavored to learn the effect of a boiling temperature on the soluble substances produced in the cultures of this germ, and the high degree of heat is re-

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sponsible for the failure of some of the experiments. It also req
some experimenting to learn that pigeons are more susceptible in w
that in summer. We published all of our experiments. M. Roux a
the charge of failure by publishing only successful experiments. Ta
all these facts into consideration, it must be admitted that our experi
published in 1886 were successful, and that they demonstrated the
duction of immunity by soluble substances contained in the culture li
in which the germ of hog cholera had multiplied. I therefore contin
claim priority for this important discovery.

SOME NEW EXPERIMENTS IN PRODUCING ANÆSTHESIA WITH NITROUS O
AND AIR, AND NITROUS OXIDE AND OXYGEN IN CONDENSED AIR-C
BERS, ILLUSTRATED BY EXPERIMENTS ON AN ANIMAL. By Dr.
HOWLAND,[1] of Washington.

THERE are forty-seven substances mentioned and described as anæsth
in the latest works on anæsthesia. Four of them, nitrous oxide, ni
oxide in mechanical combination with oxygen, ether and chloroform
the anæsthetics that have received the sanction of the medical and d
professions, as the best and safest means of producing insensibilit
pain during surgical and dental operations.

The cause of anæsthesia and the action of anæsthetics are still sub
of dispute between those who have had the largest experience in thei
ministration, and who have made the most critical experiments on an
and man; but the best methods of administering and the effects of a
thetics on the mental organism are subjects that can be demonstrate
experiment and practical experience.

Nitrous oxide has now been administered to millions of persons, a
has been proved to be almost absolutely safe as an anæsthetic for s
operations, but has proved to be dangerous and unpractical for prolo
operations on account of its effects and the want of acquired skill an
perience in its administration.

Dr. Goodwillie of New York, and myself, and a few others have bee
cessful in its administration for surgical operations; but the successfu
ministrators in the United States can be numbered on your fingers.
J. Marion Sims in a letter to Johnston Bros., dated Jan. 25, 1872,
"Since last September I have performed a great many operations o
tients under the influence of nitrous oxide. Many of these took th
for twenty, twenty-five, thirty and thirty-five minutes. One took
fifty minutes, and I saw no reason why she could not have safely tak
twice that length of time. Dr. Goodwillie has given the gas in two

[1] Dr. Howland died suddenly on his way home from the Cleveland meeting.— Ed

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iotomy cases for me; one for twenty-seven minutes, and the other for thirty-one minutes. In these it was all that I could wish."

I have administered nitrous oxide in many thousand dental operations, and several hundred surgical operations in the city of Washington, the longest time being thirty-five minutes for a capital operation performed by Dr. Bliss, assisted by Dr. Stuart. If nitrous oxide had been proved a safe and practical anæsthetic for prolonged operations, ere this it would have been in universal use, and would have taken the place of all other anæsthetics. The reason why it is not safe, is, because the blood is not oxygenated during its administration, and the patient will die of asphyxia in two and half minutes if compelled to breathe pure nitrous oxide.

If nitrous oxide is mixed with five per cent or more of oxygen, or atmospheric air, the gas is so diluted that it will not produce insensibility, and it takes a much larger quantity of oxygen or air than five per cent to prevent its being fatal to the patient from asphyxia. Prolonged anæsthesia is produced by breathing pure nitrous oxide from one-half to three-fourths of a minute till the patient is anæsthetized, and then breathing air from one-fourth to one-half a minute to partially oxygenate the blood and then breathing nitrous oxide again before the return of consciousness; recovery or death of the patient occurring within the limits of one and a half minutes. In my experiments on warm-blooded animals, death has generally occurred within two and a half minutes, the animal in a few cases living four minutes.

The non-oxydation of the blood during the breathing of nitrous oxide is proved by the livid appearance of the face of the patient, the examination of the blood of animals after death, and the chemical analysis of the expirations of persons under its influence.

From a large number of experiments, I have found that all of the nitrous oxide taken into the lungs during three-fourths of a minute of inhalation is not exhaled in this time, but as much is exhaled as of pure hydrogen or nitrogen when they are breathed for three-fourths of a minute, and no more carbonic acid is found in the exhaled nitrous oxide than in the exhaled hydrogen or nitrogen, proving conclusively that the blood is not oxygenated from the decomposition of the nitrous oxide in the circulation. Some of our most eminent men and practical chemists and physiologists are in error in relation to the decomposition of anæsthetics in the circulation and their elements forming new compounds.

We have a new anæsthetic that should claim our earnest attention. Nitrous oxide and oxygen mixed in the proportion of thirty-five parts of nitrous oxide and fifteen parts of oxygen, and administered in a condensed air chamber under a pressure of five pounds per square inch, will produce perfect anæsthesia for any length of time required, and the blood at the same time being perfectly oxygenated by the free and uncombined oxygen there is no danger or injury to the patient from a partial or entire asphyxia, as there is from nitrous oxide alone, or the still greater danger and injury from ether and chloroform. 8 (?)

In my experiments on animals with a mixture of equal quantities of nitrous oxide and atmospheric air, in comparison with a mixture of eighty-

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five parts of nitrous oxide and fifteen parts of oxygen, I find
equal in their anæsthetic effects; but the pressure in the cond
ber has to be fifteen pounds to the square inch with nitrous o
and only five pounds pressure to the square inch with nitro
oxygen.

From the thousands of operations performed in France un
ence of nitrous oxide and oxygen in condensed air-chambers,
own experiment on animals similarly anæsthetized, I believe
oxide and oxygen will be *the* anæsthetic of the future, and I thi
er facilities in administering this agent, regulating the pressu
ing the air from infectious germs in a chamber that I have
greatly facilitate its introduction.

This anæsthetic is going to be of great service to the dent
the surgeon. By increasing the pressure of air in the chamber,
tity of gas is administered, and the patient remains a much g
of time anæsthetized after ceasing inhalation of nitrous oxide
than with pure nitrous oxide as ordinarily given, thereby ena
tist to extract a large number of teeth before recovery. Refra
and those that do not readily become anæsthetized under pure
become perfectly passive and quickly insensible under nitrous
ygen. The operator is not at all affected by the escape of nit
the chamber, and he experiences no unpleasantness or injury
case with the administration of ether and chloroform. The da
of all anæsthetics is when the toxic effect of the substance t
system, paralyzes the nerve centres, and they are on the po
to control and direct vital action, or when the substance as
is taken into the lungs in a quantity that excludes the requir
oxygen to arterialize the blood, and death may occur from a
toxic point of danger from nitrous oxide, I have proved by e
animals to be beyond five hours of continued anæsthesia wh
is perfectly oxygenated with free oxygen, and the danger p
phyxia is when the volume of oxygen with the nitrous oxide
per cent of the mixture.

The danger point is therefore entirely under the control o
trator.

If a greater amount of oxygen than fifteen parts to eighty-
oxide is administered, perfect anæsthesia is not produced u
sure of the chamber is increased just in proportion to the a
gen added. When the oxygen is added it makes the whole qu
the nitrous oxide, the pressure of the chamber has to be fift
the square inch, the same as with equal quantities of nitrous

Prolonged administration of this mixture is injurious, the
longed administration of pure oxygen, causing super-oxidatio
and inflammatory action.

I have kept animals perfectly anæsthetized for two hours i
eighty parts of nitrous oxide and twenty of oxygen under
ten pounds to the square inch without any apparent injur

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of the dangerous toxic point of anæsthesia, and also the time of the danger point from asphyxia in all of my experiments with ether and chloroform have proved to be uncertain and unreliable, and the danger point to be beyond the control of the operator, death often occurring without apparent cause. Many professional men declare it criminal to use chloroform instead of ether as there are ten deaths from the former to one from the latter; while to those who survive the effects of these anæsthetics, positive injury results from chloroform in still greater proportion.

From statistics by Professor E. Andrews in the Chicago Medical Examiner, the death rate from the administration of chloroform is one in 2,723, from sulphuric ether, one in 23,404, from mixed ether and chloroform, one in 5,588, while during the year 1887, in the United States and Europe, nitrous oxide was administered to over one million persons and not a single death occurred from its use.

Is it not the duty, therefore, of every professional man to lend his influence to bring into use in every city and hospital an anæsthetic that is a hundred thousand times safer than are ether and chloroform?

I am happy to say that in my endeavors to introduce the new anæsthetic, I am meeting the almost universal approbation of the medical and dental professions.

Experiment. — An animal was placed in an anæsthetic chamber under pressure, and remained perfectly anæsthetized while the pressure was at five pounds to the square inch, but when reduced below this pressure showed signs of recovery. When the pressure was raised again, the animal became quiet; when taken from the chamber, the animal was insensible to pain but soon recovered as well as ever.

A PHASE OF EVOLUTION. By DR. E. LEWIS STURTEVANT, South Framingham, Mass.

[ABSTRACT.]

BOTANICAL varieties, the unit of evolutionary progress under vegetable culture, as evidenced by a study of the cultivated and wild dandelion. Drawings (colored) and herbarium specimens exhibited, demonstrating the substantial identity of garden varieties with wild varieties, and conversely showing the types for new varieties of the future.

[Published in full in Proceedings of the Society for the Promotion of Agricultural Science, 1888, p. 77.]

A STUDY OF THE HYDRANGÆA, AS TO THE OBJECTS OF CROSS-FERTILIZATION. By Prof. THOMAS MEEHAN, Germantown, Philadelphia, Pa.

[ABSTRACT.]

THE author details a number of facts connected with the structure and development of allied species of Hydrangea, and argues that on no theory

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of evolution based on adaptation to insect visits, could these changes occur. He contends that variety must exist, in order to provide for order,—and that variations as we see in Hydrangea can be for no special benefit to the plant but for mere variety's sake.

SOME NEW FACTS IN THE LIFE-HISTORY OF YUCCA AND THE YUCCA MOTH By Prof. THOMAS MEEHAN, Germantown, Philadelphia, Pa.

[ABSTRACT.]

THE author gives some figures in regard to the time of opening, and the duration of the flowers,—with notes on the time and duration of the moisture exudation from the perianth. The cause of the sudden stoppage of the waste is discussed, and some remarkable facts in connection with the behavior of the insect *Pronuba yuccasella*, observed by Professor Riley, confirmed.

The remarkable adaptation by which an insect is made to do the work of self fertilization, which the plant could just as readily do itself, is contrasted with similar observations in the animal kingdom.

ON THE CAUSE AND SIGNIFICANCE OF DICHOGAMY IN FLOWERS. By Prof. THOMAS MEEHAN, Germantown, Philadelphia, Pa.

[ABSTRACT.]

THE author repeats the announcement of his discovery, already made through the Proceedings of the Academy of Natural Sciences of Philadelphia, that it takes a longer-continued amount of heat to excite growth in the female than the male organs of flowers; and that varying seasons will, therefore, advance or retard the several sexual organs accordingly. So there is absolutely nothing in connection with the visits of insects to account for dichogamy, which is solely an accident of climatic environment.

ADAPTATION IN THE HONEYSUCKLE, AND INSECT VISITORS. By Prof. THOMAS MEEHAN, Germantown, Philadelphia, Pa.

[ABSTRACT.]

THE author gives all the points in the flowers of certain honeysuckles, and the development of the extraordinary amount of nectar from which the family derives its common name, and shows that the insects which visit the flower for the sweet secretions take no part in the pollination of the flower, which office is performed by pollen-gathering insects for which no special adaptation has been made, and which rather aid self- than cross-fertilization.

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NOTES ON THE INFLORESCENCE OF CALLITRICHE. By Prof. JOSEPH SCHRENK, New York College of Pharmacy (Hoboken, N. J.).

[ABSTRACT.]

THE inflorescence briefly described. The bracts, considered as stipules by Caspary and as trichomes by Schenck, are really sacs or bladders filled with air. Their appearance, structure and development described. Their function is to increase the buoyancy of the tufts of leaves with the pistils and stamens in their axils. The palm-shaped hairs at the nodes are probably secretory organs. The histology of the fibro-vascular bundles shows that when pistil and stamens occur in the same axil, they are to be considered as a perfect flower.

HYGROSCOPIC MOVEMENTS IN THE CONE-SCALES OF ABIETINEÆ. By Prof. ALBERT N. PRENTISS, Ithaca, N. Y.

[ABSTRACT.]

IN most of the Abietineæ, soon after the maturation of the cones, the persistent scales fold backward, or outward from the axis, to permit the ripened seeds to escape. The scales are very sensitive to moisture, and in many species exhibit very rapid movements when wet, as with rain. This is especially well seen in the cones of *Tsuga Canadensis*, in which the widely-open scales become completely closed in twelve minutes.

This property of the cone scales, is found to be very efficient; first in loosening the seeds with their attached wing from the scale which bears them; and second, in favoring the wide dispersion of the seeds, as the cones open and close many times before all the seeds are sown, thus securing their transport in different directions by the varying winds.

SEXUAL CHARACTERS OF THE SPECIES OF THE COLEOPTEROUS GENUS LACHNOSTERNA. By JOHN B. SMITH, U. S. National Museum, Washington, D. C.

[ABSTRACT.]

THE species of *Lachnosterna*, though large in size, have always been most difficult to separate. The most recent work of Dr. George H. Horn on this genus has aided in the separation of the species, while not clearing up doubts in all the cases. In examining a very large series of freshly captured specimens, differences in sexual structure of the males became apparent, which cleared up all doubts of the specific limitation of species, and examination of a series of females confirmed the conclusions drawn from the males. Heretofore determination of the ♀ has been difficult

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without having also the ♂ at hand. In entomological literature thu
there has been considerable attention paid to these structures of the
while I cannot find that the genitalia of the females have been exam
As a matter of fact they are correlated to those of the ♂, and every
fication of the male is accompanied by a corresponding difference i
female. The further fact developed in the course of investigation,
there was absolutely no variation in these structures in either sex, w
the limits of a species. The conclusions are therefore that however
able in superficial characters of color, vestiture, within some limi
sculpture as well, identity of genital structure indicates identity of spe
while however similar in superficial characters, difference in genitali
dicates difference of species.

ON THE STRUCTURE OF THE SKULL OF THE LARVA OF AMPHIUMA. By
O. P. HAY, Irvington, Ind.

[ABSTRACT.]

THIS paper described the structure of the skull of the larva of *Amph*
while still within the egg, but near the time of hatching. The exa
tion showed that its development is much further advanced than is
of related forms when they are excluded. There is a large fontane
the base of the skull on each side of the cranial notochord. The trabe
are slender, enclosing a large fontanelle and meeting in the nasal re
The cranial walls are low and the brain is mostly protected abov
membrane alone. The otic capsules are large and have coalesced
the trabeculæ. The condyles are prominent and are ossified. The sus
sorium has three processes: pedicle, otic process and an ascending pro
Articulated to its posterior edge is a rod of cartilage, which overlie
facial nerve.

The hyoid is partially ossified, as is also a portion of the first bran
arch.

The following membrane bones are developed: premaxillaries, vo
frontals, parietals, squamosals, dentaries, angulo-splenials. No ma
ries are seen, but a row of dental papillæ shows where they will sh
appear.

NOTICE OF A SUPPOSED NEW SPECIES OF BRANCHIPUS FROM INDIANA.
Prof. O. P. HAY, Irvington, Ind.

[ABSTRACT.]

MOST closely related to *B. bundyi* from Jefferson, Wisconsin. Di
therefrom in that the female has growing out from each dorso-lateral
face of the tenth segment a prominent lobe or process. Found at Irving
Indiana. Named *B. Gelidus*, W. P. Hay.

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COLOR VARIATIONS OF NEBRASKA FLYING SQUIRRELS. By Prof. W. EDGAR TAYLOR, State Normal School, Peru, Neb.

[ABSTRACT.]

THE American flying squirrels present a range of geographical variation in size quite unparalleled in other members of the squirrel family. On the other hand the coloration is remarkably constant, almost exceptionally so; specimens from the same locality sometimes differ in the color of the dorsal surface as much as the most diverse examples from widely separated localities. Two varieties are recognized by naturalists, probably grading into each other. From a careful examination of typical specimens of the flying squirrel from Nebraska we may conclude:

1. The measurements correspond to the northern variety, while the colors correspond more nearly with the southern variety.
2. The local variations, in colors, are very great; these variations existing even in members of the same nest.
3. Locally, at least, the two varieties appear to grade into each other.
4. The degree of coloration on the same parts of different specimens does not vary in the same ratio.

THE MUSCLES OF THE SOFT PALATE IN THE DOMESTIC CAT. By Prof. T. B. STOWELL, Cortland, N. Y.

[ABSTRACT.]

THIS contribution to comparative anatomy is preliminary to an inquiry into the phylogenesis of the *uvula palati*. Two preparations are necessary for the study of the muscles of the soft palate; a hemisected and a transected head. In the *hemisection* can be seen to best advantage the relations of the respiratory and the alimentary passages, the eustachian tube, the tonsil and the epiglottis. The following muscles should be dissected in the same section: the levator, the pharyngo-staphyle and the glosso-staphyle. In the *transection* should be studied the length of the palate and its function in closing the passage from the oral to the pharyngeal cavity, thereby insuring an exclusively nasal respiration; in this section are demonstrated the origins of the levator and the tensor muscles.

The soft palate is a continuation of the hard palate without the osseous plate. The muscles are striated, paired, receive their blood-supply from the ectal carotid artery and are innerved by the trigeminus, the facial and the glosso-pharyngeal nerves. The staphyle muscles shorten the velum and close the postnares. The levators act upon the middle of the velum and are most active in closing the postnares. The dilation of the ventral opening of the eustachian tube, usually referred to the tensor muscle, may be due to the action of the levators in closing the postnares so firmly that the forcible introduction of air expands the tube and drives the tympanic membrane laterad.

The tensor gives firmness to the palate especially in deglutition. The pharyngo-staphyle and glosso-staphyle muscles close the *isthmus of the fauces* in deglutition.

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COMPARISON OF THE FLORA OF EASTERN AND WESTERN MICHIGAN IN THE LATITUDE OF 44° 40'. By Prof. W. J. BEAL, Agricultural College, Mich.

[ABSTRACT.[1]]

ON the western shore next to Lake Michigan, we find many southern plants not found on the eastern; on eastern many northern plants not found on western. Lists were given.

OBSERVATIONS ON THE SUCCESSION OF FORESTS IN NORTHERN MICHIGAN. By Prof. W. J. BEAL, Agricultural College, Mich.

[ABSTRACT.[1]]

A STUDY of virgin forests shows very old, stunted plants like those in cleared land near by, excepting some coniferæ which are killed by fire. Fire has more than once been through some of the forests studied, as shown by the former killing of small trees to the ground. *Pinus Banksiana* is admirably adapted to succeed itself, as it fruits young, fruits abundantly, seeds retain vitality in cones closed up often for seven years or more. Some cones do not open until trees are killed by fire, then seeds drop on ground ready to favor growth.

THE SYSTEMATIC POSITION OF THE RHIZOCARPEÆ. By DOUGLAS H. CAMPBELL, Detroit, Mich.

[ABSTRACT.]

A. THE present position of the *Rhizocarpeæ*.

B. Outline of the work of different investigators on the Rhizocarpeæ.

C. Review of the author's work on various members of the order, and comparison with other Pteridophytes.

D. Conclusions.

POLLEN GERMINATION AND POLLEN MEASUREMENTS. By Dr. BYRON D. HALSTED, Agricultural College, Iowa.

[ABSTRACT.]

1st part—(1) The old methods of germination. (2) Tests on glass slides—in watch-glasses—in artists'well-slabs. (3) The control the method offers. (4) Facilities for comparative study of pollen.

2nd part—Measurements. (1) When dry and what is shown. (2) When wet and points demonstrated. (3) Importance of measurements being taken for both wet and dry pollen.

[1] Printed in full in the Report of the Michigan State Board of Agriculture for 1888.

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OBSERVATIONS ON THE HOUSEBUILDING HABIT OF THE MUSKRAT. By AMOS W. BUTLER, Brookville, Ind.

[ABSTRACT.]

THIS paper gave some observations on the structure of muskrat homes, noting certain changes that have occurred in the habits of the animal within historic time. The author also referred to the extension of the housebuilding habit and its rate of advancement, devoting attention to the causes of the changes noted. The observations were all made within the southeast quarter of Indiana.

METAMORPHOSIS IN THE PLEURUM OF ALEURODES. By Prof. HERBERT OSBORN, Ames, Iowa.

[ABSTRACT.]

OBSERVATIONS on a species of *Aleurodes* during prepupal, pupal, and the imago stages show that the pleurum in prepupal stage is equal in extent, and not separable from the scales; that during the pupal stage it is detached from scale and in meso-and meta-thorax is rapidly altered in structure, while in prothorax and abdominal segments lobes are clearly defined. In the fresh imago slight pressure from above causes the extrusion of these lobes on prothorax and abdomen, showing that the pleurum is simply contracted to form the walls of the body, while no such expansion in meso- and meta-thorax indicates the modification of this portion of the pleurum to form the wings. Specimens showing these different steps in development were submitted for examination.

ENTOMOLOGICAL MEMORANDA. By Prof. O. S. WESTCOTT, Maywood, Ill.

[ABSTRACT.]

(1) Further evidence of the carrion-loving propensities of certain diurnal Lepidoptera.

(2) Alleged seasonal varieties of *Melitæa tharos*, viz., *marcia* and *Morpheus* equally abundant in the latter part of July at Port Arthur, Ontario, Canada.

(3) Pupation of nocturnal larvæ on a gravel walk.

(4) Evidence of the greater abundance of *Lachnosterna gibbosa* Burm. than that of *Lachnosterna fusca* Fröhl, in some localities.

(5) Vast numbers of *Crambidæ* taken at light.

(6) A successful insect trap.

A PLEA FOR UNIFORMITY IN BIOLOGICAL NOMENCLATURE. By Dr. N. L. BRITTON, Columbia College, New York.

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ANTHROPOLOGY.

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ADDRESS

BY

DR. CHARLES C. ABBOTT,

VICE-PRESIDENT, SECTION H.

EVIDENCES OF THE ANTIQUITY OF MAN IN EASTERN NORTH AMERICA.

An ecclesiastical body has recently decided, by a significant vote, that man, perfect in all his parts, had been created *de novo* from the dust — that the law of evolution has nothing whatever to do with him or his; if, indeed, it is not a very flimsy figment of the imagination, and a harmful plaything with which men who aim to be scientific, or rational, solace themselves, because, in their foolhardiness, they decline to accept the asserted initial separate creation of all living beings, from the highest to the lowest, now living or that have lived.

If this decision of an ecclesiastical body really represented the truth, instead of being a painful exhibition of stultifying ignorance, Anthropology would be shorn of much of its attractiveness, and the term "prehistoric" would have little, if any, meaning. In such a case, the races of America would scarcely be worthy of consideration, being but the rapidly degenerated and discolored descendants of the physically perfect, yet painfully weak-kneed Adam of Paradise.

There is, on the contrary, unquestionably but one method of correctly interpreting the past, as to the history of man, and that is to adopt the same methods and draw the same inferences as have been done in tracing the evolution of the horse, camel, elephant or ox. This, strangely enough, seems repugnant to very many who feel that any relationship, however remote, with less intelligent creatures is a reflection upon their own intelligence; while, in fact,

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they compromise their claim to a high intellectual standard only when they deny their purely animal origin.

To determine at what precise point in geological time, man appeared upon the earth, is, it seems to me, obviously impracticable, from the fact that the dividing line separating humanity from the non-human cannot be drawn. It were as easy to name the moment when the gloaming merges into night, or shout with confidence, now! as the dawn brightens into day. Nor is it demonstrable, with our present knowledge, to point to that country where the momentous change first took place, if it occurred but once. At present, however, we can safely say that Miocene man is extremely problematical, and Pliocene man a question as yet unsettled; the auriferous gravels of California being pronounced late Tertiary by Whitney, and by LeConte as representing "the beginning of the Glacial Epoch."

At all events, we have neolithic man as far back as the Glacial Epoch and possibly in the Pliocene. Man in the Tertiaries, therefore, championed by my honored predecessor, Professor Morse, becomes something more tangible than a hypothetical creature. Professor Putnam has pithily outlined this important subject in a recent communication to the Boston Society of Natural History. He there remarks: "When we compare the facts now known from the eastern side of the continent, with those of the western side, they seem to force upon us to accept a far longer occupation by man of the western coast than of the eastern; for not only on the western side of the continent have his remains been found in geological beds unquestionably earlier than the gravels of the Mississippi, Ohio and Delaware valleys, but he had at that early time reached a degree of development equal to that of the inhabitants of California at the time of European contact, so far as the character of the stone mortars, chipped and polished stone implements, and shell beads, found in the auriferous gravels, can tell the story. On the Pacific coast, where the conditions of life were more favorable, he had passed beyond the palæolithic stage before his works were buried in the gravels under the beds of lava; while at a later period on the Atlantic coast he was still in the palæolithic stage. Either this must be accepted, or else the geological changes on the Pacific coast have been entirely misunderstood; for we can no longer question the many instances of the discovery of the works of man, and also of his bones, in the Californian gravels. The

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same story is told by the beautifully chipped implement of obsidian found by Mr. McGee in the quaternary deposits of Lake Lahontan in Nevada."

Man in America, therefore, must be studied from a geological standpoint; and not only, as we have seen, is this true of the Pacific coast, but signally so, when, coming eastward, we reach the Mississippi.

Mr. Warren Upham has, during the present year, published in full, a lucid account of his careful examinations of the drift formations at, and in the vicinity of Little Falls, Minnesota, where, in 1879, Miss Babbitt found those extremely rude but unquestionably worked quartzes, concerning which there has been much needless comment, unfavorable to their human origin or their asserted antiquity, even from presumably learned sources; and, of course, lame attempts to belittle the discovery by those who should know better are still heard.

The conclusion of Mr. Upham's paper is as follows: "While the deposition of the valley-drift at Little Falls was still going forward, men resorted there, and left, as the remnants of their manufacture of stone implements, multitudes of quartz fragments. By the continued deposition of the modified drift, lifting the river upon the surface of its glacial flood-plain, these quartz chips were deeply buried in that formation. The date of this valley-drift must be that of the retreat of the ice of the last glacial epoch, from whose melting were supplied both this sediment and the floods by which it was brought. The glacial flood-plain, beneath whose surface the quartz fragments occur, was deposited in the same manner as additions are now made to the surface of the bottom-land; and the flooded condition of the river, by which this was done, was doubtless maintained through all the warm portion of the year, while the ice-sheet was being melted away upon the region of its head-waters. But in spring, autumn and winter, or, in exceptional years, through much of the summer, it seems probable that the river was confined to a channel, being of insufficient volume to cover its flood-plain. At such time this plain was the site of human habitations and industry."

In 1883, as the result of exhaustive studies of glacial deposits, from New Jersey westward, across Ohio, Rev. G. Frederick Wright predicted that traces of palæolithic man would be found in the latter state. Commenting upon such evidences as occurring else-

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where, he remarks: "Man was on this continent at that period when the climate and ice of Greenland extended to the mouth of New York Harbor. The probability is that if he was in New Jersey at that time he was also upon the banks of the Ohio, and the extensive terrace and gravel deposits in the southern part of our state should be closely scanned by archæologists. When observers become familiar with the rude form of these palæolithic implements they will doubtless find them in abundance."

Palæolithic implements, concerning which there can be no doubt, have not been discovered in abundance as yet, but Professor Wright's belief proves to have been well founded. Dr. C. L. Metz of Madisonville, Ohio, has discovered two specimens which set the matter at rest. Both were found at significant depths; one of them, nearly thirty feet below the surface. The region, where found, is one characterized by immense gravel deposits of glacial age and origin. They have been carefully studied and reported upon by Prof. Putnam and by Mr. Wright, who remarks, in conclusion, with reference to the discoveries of Dr. Metz:

"In the light of the exposition just given, these implements will at once be recognized as among the most important archæological discoveries yet made in America, ranking on a par with those of Dr. Abbott, at Trenton, N. J. They show that in Ohio, as well as on the Atlantic coast, man was an inhabitant before the close of the glacial period. We can henceforth speak with confidence of interglacial man in Ohio. It is facts like these which give archæological significance to the present fruitful inquiries concerning the date of the glacial epoch in North America. When the age of the mound-builders of Ohio is reckoned by centuries, that of the glacial man who chipped these palæolithic implements must be reckoned by thousands of years."

Mr. Hilborne T. Cresson will, at this meeting, present notices of his discovery of two chipped implements of argillite which he found *in situ*, at a depth of several feet from the surface, in railroad cuttings through the old terrace of the Delaware river in Claymont county, Delaware. The geological position of these specimens will excite discussion, but their great age will not be questioned. Of particular interest in relation to discoveries in the gravels at Trenton and Ohio, is the discovery of a large flint implement found by Mr. Cresson in the glacial gravel in Jackson county, Indiana. An account of this specimen will also be presented to this section dur-

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ing the meeting by Professor Putnam for Mr. Cresson. I am permitted to call attention in advance to these new facts in the distribution of palæolithic implements, and I may add that it is of extreme importance that these rude implements from New Jersey, Delaware, Ohio, Indiana and Minnesota are in the Peabody Museum at Cambridge, where they can be freely studied and compared with each other and with the specimens from the gravels of the old world.

Nor are these instances of the discovery of palæolithic man, in North America, all that are upon record; but are they not enough? Why, indeed, should the bare mention of the poor fellow's name still excite a sneer? There will probably always be over-cautious folk who will only accept *cum grano salis*, the Man of the Tertiaries, however eloquently he may be plead for; but no one willing to accept other testimony than his or her own eyes—often the most treacherous of guides—can in fairness turn their backs, when we speak of that primitive chipper of flinty rock, who, with no other weapon, at least, held at bay, the savage beasts of primeval times; and who, with a cunning that is ever better than mere strength of limb, proved a powerful foe of both the mammoth and the mastodon. Such a man stands out in the geological history of the Mississippi and Ohio valleys, not as a dim shadow, but a substantial fact.

Was he confined to these two portions of the country? By no means. On the contrary, it would appear that as either seaboard was neared, his numbers increased, and that as a coast-dweller he preëminently flourished. In the valley of the Delaware river palæolithic man has left such abundant traces of his former presence, in the form of rudely-fashioned stone implements, that for long they were considered as the hasty or unfinished work of the later Indians.

As the first to point out what is now maintained by competent archæologists to be their real significance, I may be pardoned for devoting the conclusion of my address to a consideration of that region—the Delaware valley—so far as its physical character and the traces of prehistoric man found there have a bearing on the question of the antiquity of Man in America.

The literature of the subject is now so considerable—not including the inanities of the ignorant—that a brief résumé would of itself outreach reasonable limits, and I purpose therefore to confine myself more particularly to the results of my own work. But do

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not suppose that others have not carefully gone over ground. Shaler, Belt, Whitney, Wright, Pumpelly, McG Lewis and our State Geologist, Cook, as geologists are one in their view that the gravel deposits are so far an be very significant as to whatever traces of man or other they may contain; while Dawkins, Tylor, Putnam, Mors Wilson and De Costa have all been more or less success ing traces of palæolithic man in this river valley, and out qualification, his former presence.

The question may now be asked, what is a palæoli ment? It is not very readily defined as there is consi riation in the shape; but as I understand the signific term, it is properly applied to coarsely chipped mass rock upon which a distinctly designed cutting edge is which is often added an acute point. Furthermore, the mistakable evidence of antiquity by the weathering of faces, and they are found as a rule, but not necessarily deposits of glacial or river drift with which they agree

How far do these Trentonian Implements meet wit quirements? As their discoverer, I prefer to give the others, rather than my own. This is what Dr. M. E. W the lithologist, has said of them: "Certain of these spec placed in my hands in 1876 for examination, their character then being unknown. They were found by m and microscopic examination to have been made fro greatly indurated, and breaking with a conchoidal frac specimens were weathered to a greater or less extent plainly that the fractures must have been made long ag small fractures of secondary character occur. This chipping evidently took place long after the original but also long ago, as is shown by the weathering of the both the primary and secondary fractures. The few fractures are probably natural, and could easily occur to the action Dr. Abbott supposes. The original chip not have taken place by any known natural causes a rocks, so far as the writer has any knowledge. Of cou brings us to the only agency that could do the work— characters of the specimens, petrographically, bore ou ments made to me by Mr. Putnam, of the conditions u they were found, whether upon the surface or in the gra

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not see how it is possible that such correspondence of characters could exist unless the specimens were found under the conditions reported.

The lithological characters then show that the specimens are not natural forms; that being composed of a slow weathering rock, they must have been made long years ago; that many years later they were subject to other conditions, probably natural, by which part have been modified; that since then, they have lain for many, many years exposed to weathering agencies; some showing that they have been subject to this action while lying on or near the surface, and others while buried to some depth.

Their weathering corresponds to that observed on pebbles of similar composition in gravels elsewhere. It is to be remembered that all the weathering has taken place since the Abbott specimens were originally chipped.

The term weathering, as here employed, means the alteration and decay that have taken place on the *surface* of the *specimen*, but does not imply that it has been exposed on the *surface* of the *ground;* it may or may not have been; the weathering itself shows with greater or less clearness whether this occurred from surface exposure or not.

Part of the specimens shown me bore evidence that they had originally been exposed to weathering on the surface of the ground and been covered since, but the covering evidently took place ages ago, if the weathering that they have been subjected to since is any criterion.

The term "argillite," as employed by me, is used to designate all argillaceous rocks, in which the argillaceous material is the predominant characteristic; slate or clay-slate, clay-stone, etc., are simply varieties of it, the term slate being only rightfully used when slaty cleavage is developed. The argillite out of which these specimens were made has no trace of cleavage."

According to Professor Haynes, a skilled observer, who has given much time to the study of palæolithic man in Europe, as well as in this country, "the term palæolithic is primarily restricted in meaning to such objects . . . . when met with under peculiar geological conditions; that is to say, when found embedded in the gravels which have been deposited by certain rivers during the period known to the geologists as the quaternary or pleistocene period. At that time their volume of water was much greater

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than it now is, which was caused by the melting of the grea
cap that once covered the northern portion of both continent
companied by a climate much more humid than we have at pre
Such accumulations of gravel are often of very great thick
and embedded in them, side by side with the stone implen
above described, are found the fossil bones of extinct speci
animals, such as the mammoth." After mentioning, in the
paper, the various localities in Europe that he had carefully e
ined, he remarks with reference to the locality under consi
tion:

"From these various experiences I feel myself warranted in
ing that the general appearance of the country and the char
of the gravels at Trenton, N. J., present a most striking re
blance to what I have seen in the various localities in the
World to which I have referred. There is the same rudely s
fied mingling of coarse materials marked by a similar absen
clay . . . . . Speaking . . . from an archæological s
point, I do not hesitate to declare my firm conviction that the
argillite objects found in the gravels of the Delaware river, at
ton, N. J., are true palæolithic implements."

My own impressions of their true character was not sud
reached. The evidence, of other kind, of the antiquity of th
dian, led me to consider them as rude objects made for some t
purpose and discarded. Later, I became convinced that they
older than ordinary surface-found relics, and assumed that th
dian of history commenced his career in this valley while i
palæolithic stage of culture.

Thus, while pursuing my collecting of Indian relics, it was
ually forced upon my mind that these rude implements were
intimately associated with the gravel than with the surface o
ground and the relics of the Indians found upon it.

Acting upon this, I continued for two years to examine
carefully both the surface of our fields and every exposure o
underlying gravels; and in June, 1876, after having found se
chipped implements *in situ*, expressed the opinion that the
ware river, "now occupying a comparatively small and sh
channel, once flowed at an elevation of nearly fifty feet abo
present level; and it was when such a mighty stream as this
man first gazed upon its waters and lost those rude weapons
swift current, that now, in the beds of gravel which its

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have deposited, are alike the puzzle and delight of the archæologist. Had these first comers, like the troglodytes of France, convenient caves to shelter them, doubtless we should have their better wrought implements of bone to tell more surely the story of their ancient sojourn here; but wanting them, their history is not altogether lost, and in the rude weapons, now deeply embedded in the river's banks, we learn, at least, the fact of the presence, in the distant past, of an earlier people than the Indian."

Thus it will be seen that I have been fairly cautious in my statements and slow in reaching any conclusions with reference to these implements which separated them from ordinary Indian relics.

In September, 1876, Mr. Putnam, the Curator of the Peabody Museum of Archæology at Cambridge, Mass., favored me with a visit, and together we carefully examined the river bluff below Trenton, and succeeded in finding *two* specimens *in situ*, such as I had previously described in the American Naturalist. At his request, I continued my examinations of these gravels, acting under an appropriation made by the Peabody Museum for this purpose; and, in November of the same year, submitted to him a report *On the Discovery of Supposed Palæolithic Implements from the Glacial Drift in the Valley of the Delaware River, near Trenton, New Jersey*. Still realizing how all-important it was in this matter to make haste slowly, I purposely referred to these chipped stones as *supposed* palæolithic implements, and gave, in detail, my reasons for thus considering them.

Referring to this report, Mr. Putnam remarked, in his annual report to the trustees of the Peabody Museum, that "from a visit to the locality with Dr. Abbott, I see no reason to doubt the general conclusion he has reached in regard to the existence of man in glacial times on the Atlantic coast of North America."

Before this report was published these gravel deposits were visited by Prof. N. S. Shaler, who was fortunate enough to find a characteristic specimen, but not *in situ*. I also found one, likewise in the talus. Of these specimens, Professor Shaler says; "Although the whole face of the escarpment is in motion, creeping slowly under the influence of frost and gravity towards its base, it was difficult to believe that these specimens, found about twelve feet below the top of the bank, had travelled down from the superficial soil."

Continuing my own researches, in 1877, I made a second report

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on the occurrence of these implements, and re-affirmed my conviction that in the specimens of artificially chipped pebbles, from these gravel deposits, we have evidence of man's presence at an earlier date than the supposed advent of the Indian; and referred them geologically to the glacial epoch, in accordance with the writings of Professor Cook, state geologist of New Jersey, who had pronounced these gravels as of glacial origin.

This, briefly, is the history of my own labors in this field; labors continued to the present time and with results that have invariably confirmed my impressions, as I have outlined them.

But admitting that a given class of stone implements is characteristic of a given deposit of gravel, and I think we must admit this now, what is the geological history of this deposit? Is it too recent to be of special import, or too ancient to be of archæological significance? Both views have been held, and neither proves tenable. That the former view should have found supporters is indeed strange. Certainly there is now no movement of the gravel by the river, whatever its condition or freshet stage; and certainly, if these rude forms were of identical origin with common Indian relics, then rude and elaborate alike,—jasper, quartz, porphyry and slate together; axes, spears, pottery and ornaments, all of which are found upon the surface, should have gradually become commingled with the gravel, even to great depths. Any disturbance that would bury one, would inhume alike the various forms of neolithic implements. Such, however, is not the case.

How old and not how recent are the Delaware valley, or, as they are now known, Trenton gravels? This, it is all-important, should be definitely determined. Until recently, there has been the widest range of opinion upon this point, and so great an antiquity claimed, that it was wholly incredible that man should then have lived. How true it is, as Professor Morse has tersely remarked, "Man, profoundly interested in his origin and antiquity, finds himself hampered in his investigations by the opinions and prejudices that have grown up with him. He finds it well-nigh impossible to step outside of himself and regard himself as a mammal among hundreds of other species of mammals."

Depending upon others for my geology, under the circumstances mentioned, it can readily be understood why I was often so sadly bewildered. It was not only an instance of many men of many minds, but occasionally the same individual with numerous opin-

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ions. Archæological investigation, under such circumstances, was an up-hill task, the path to the truth being blocked by the obstacles that ignorance, prejudice and hasty conclusions heaped about it; but all the while, the gravel-beds themselves were inexorable and continued to yield evidences of man in spite of the interdictions of the baffled prophets.

A clear light was finally thrown upon these implement-bearing gravels, as the result of a careful study of them, from a geological standpoint, by Rev. G. Frederick Wright, who, as we have already seen, has determined the relationship of all such deposits, lying immediately south of the terminal moraine, to that greater deposit, and so given us approximately, their own age and connection with the last glacial epoch.

It is not necessary to give in detail, the conclusions reached by Mr. Wright. Suffice it to say, that he shows these gravels to be the last important result of the glacial epoch, the direct result of the melting of the glaciers, as they retired northward; and that while this was in progress, the rude implements of palæolithic man were lost and embedded in them.

Admitting this, how long ago did it take place? How great an antiquity does it imply? In this matter, Mr. Wright has been very generous, for which we are duly thankful, for the archæologist has an almost insatiable appetite, never yet having had his fill of ages.

Concerning the antiquity of palæolithic man in North America, Mr. Wright has remarked as follows:

"A word may properly be said with reference to the bearing of these facts upon the date of man's appearance in America. In the first place, it should be observed that, to say man was here before the close of the glacial period only fixes a minimum point as to his antiquity. How long he may have been here previous to that time must be determined by other considerations. Secondly, with our present knowledge of glacial phenomena, the date of the close of the glacial period is regarded as much more modern than it was a few years ago. Sir Charles Lyell's estimate of 35,000 years as the age of the Niagara gorge, which is one of the best measures of post-glacial time which has yet been studied, is greatly reduced by what we now know of the rate at which erosion is proceeding at the falls. Ten thousand years is now regarded as a liberal allowance for the age of that gorge. But, finally, the term "close of the glacial period" is itself a very indefinite expression. The glacial period was

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a long time in closing. The erosion of the Niagara gorge began at a time long subsequent to the deposit of the gravel at Trenton and at Madisonville. Between those two events time enough must have elapsed for the ice-front to have receded a hundred miles or more, or all the distance from New York to Albany; since only at that stage of retreat would the valley of the Mohawk have been freed from ice so as to allow the Niagara River to begin its work. The deposits at Trenton and Madisonville took place while the ice-sheet still lingered in the southern watershed of New York, Pennsylvania and Ohio," and in a letter to me, bearing upon this question, he has kindly added, "you have got all the time you need, so far as I can now see." This is certainly encouraging! There was a time when, to all appearances, American archæology would have to be squeezed into the cramped quarters of ten thousand years; but we are pretty sure of twenty or even thirty thousand now, in which to spread out in proper sequence and without confusion the long train of human activities that have transpired during prehistoric time.

Mr. McGee, at the last meeting of this Association, in giving the results of his studies of the Columbia formation, remarks as follows: "It has been inferred from the relation of the Columbia formation to the terminal moraine and the drift-sheet which it fringes, that the older deposit represents a period of quaternary cold, much earlier, much longer continued, and accompanied by much greater submergence, than the epoch of cold represented by the newer deposits; and it has been inferred from the relative erosion of water-ways since the two deposits—Columbia and latest glacial—were formed that the interval of mild climate and high level of the land between the two epochs of cold was from three to ten times as long as the postglacial period. These inferences are fully sustained by a long series of observations extending over three years of time and many thousand square miles of area."

If then, we accept the most moderate estimate of the length of postglacial time, some six thousand years, we have of interglacial time (*i. e.*, between the first and second epochs) from eighteen thousand to sixty thousand years, and to this, as I understand the matter, must be added, the long stretch of time during which the second epoch of cold continued. Assuming, therefore, that geologists have made no mistake, archæology has time enough and to spare. At no time was the continent uninhabitable, however thick

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and wide-reaching the ice, or deeply submerged the lower lying areas. Still there was land enough for mammalian life in all its glory, and it flourished at the very foot of the advancing ice-sheet, and reëntered every tract as the glaciers withdrew. Then we had the mastodon and mammoth, reindeer and bison, musk-ox and moose and Man familiar with them all.

In November, 1887, Mr. McGee presented to the Anthropological Society of Washington, a communication on "The Conditions of Accumulation of the Trenton Gravels." As it gives the clearest description of the geological conditions of the neighborhood, I propose to quote freely from an abstract of the paper kindly furnished me by the author.

Mr. McGee says: "There are, in the vicinity of Trenton, N. J., two distinct gravel deposits widely different in age. The first is a mass of current-bedded pebbles, cobbles, bowlders and coarse sand, generally graduating upward into a homogeneous loam or brick clay containing rare bowlders; the deposit rises to altitudes of perhaps two hundred and fifty feet in the latitude of Trenton, covers the surface generally as a mantle of variable thickness up to fifty or sixty feet and is sometimes fashioned into terraces—through one of the best examples of which the Delaware river has cut a moderately broad gorge in the upper part of the city of Trenton; the brick clays and gravel deposits along the Delaware river . . . the Columbia formation of the present author (McGee) . . . represent a sub-estuarine or submarine delta of the Delaware river, together with associated littoral deposits formed during the earlier epoch of cold of the Quaternary when the land in the latitude of Trenton was submerged two hundred and fifty feet or more.

The second gravel deposit is confined to an irregular area of the lowlands on both sides of the Delaware river above its great bend at Bordentown. It is composed of pebbles and cobbles (most of which are well rounded), together with scattered bowlders, embedded in a scant matrix of sand, loam and silt; the surface of the deposit is generally horizontal save where cut by recent drainage and its base is irregular; its maximum thickness reaching perhaps forty or fifty feet. It is evidently water-laid, though its bowlders appear to be ice-dropped, and it unquestionably is the southernmost extension of the overwash gravels from the terminal moraine formed during the later epoch of cold of the Quaternary when the

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land was depressed as far southward as Philadelphia. It is to this deposit that the name 'Trenton Gravels' has been applied, and its interest to anthropologists lies in the fact that palæolithic implements are abundantly embedded within it.

The configuration and structure of the Trenton gravels alike indicate that they were deposited within and practically filled an estuary of the Delaware river contemporaneous with the later northern ice sheet and the hypsometric and geographic distribution of the deposit indicates the geographic conditions existing above the head of the Delaware Bay at that period. Restored in accordance with the testimony of the Trenton gravels the Delaware Bay of late quaternary time is transmuted from its present condition to a narrow tidal river, similar to the lower Hudson, extending from the terminal moraine to Trenton, and there expanding suddenly into a broad estuary analogous with that of the Susquehanna at its embouchure into Chesapeake Bay; indeed, the ancient Delaware Bay so closely resembled the present Chesapeake Bay that the latter conveys a definite conception of the former. The depression of the ice-burdened land extended southward barely to Philadelphia, and thus the tidal waters occupied a considerable area similar to the expanded head of Chesapeake Bay. Into this ancient Delaware Bay the great river, fed by the melting ice sheet, swept its detritus to be distributed by the waves and deposited in horizontal layers; and during the seasons of most rapid melting, ice floes formed nearer the margin of the glacier, bore the sand, pebbles and bowlders collected in the upper reaches of the river into this bay and there they floated in the currentless waters until they dropped their burdens, just as do the smaller ice floes in the Chesapeake Bay of to-day; while the finer detritus was mainly deposited in the upper reach of the river as is the case to-day in the Hudson. Meantime, the northern ice was a hundred miles away and did not prevent primitive man from assembling about the low and hospitable shores of the miniature sea which was probably the home of fish and fowl just as Chesapeake Bay is now the haunt of myriads of ducks and geese, and a famous fishing ground; and over the bosom of the bay, little affected by tide because of its distance from the ocean, and little disturbed by waves because of its shoalness, palæolithic man may have floated on the simplest craft or even have waded in the shallow waters, as either primitive or civilized man might in the modern Chesapeake. These are the

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conditions under which the Trenton gravels were accumulated and the presence of contemporary man is attested by the examples of his handiwork in all horizons of the deposit.

It is significant that all [nearly all—C. C. A.] the palæolithic implements found in the Trenton gravels are of like material—*i. e.*, a variety of argillite—and that natural pebbles of this material are rare in the formation. It occurs *in situ* . . . . not far from the Quaternary ice margin, and bowlders of it are occasionally found in the deposit about Trenton, but its occurrence in the form of pebbles is so rare as to indicate that the implements must have been manufactured at a distance and carried by human agency to the ancient Delaware to be lost beneath its waters. It is significant, too, that the demonstrably artificial objects are least abundant toward the base of the deposit which was laid down before the geographic conditions above indicated were fully developed and that they increase in abundance upward culminating in the superior portion of the deposit formed when the geography of the ancient Delaware most closely approached that of the present Chesapeake; finally, it is significant that the distinctive palæolith found within the Trenton gravel are also found on the adjacent surface made up of the older (Columbia) gravels associated with implements of more modern type, but that they are exceedingly rare over the surface of the Trenton gravels themselves upon which the more modern implements are common.

It should be noted that by study of the Trenton and Columbian gravels in conjunction with investigations of the terminal moraine and other glacial deposits farther northward, the Quaternary history of the region about Trenton has been elucidated. It has been ascertained that the Quaternary period of the geologists comprised two great epochs of cold . . . . and it is noteworthy that all of the remains of palæolithic man thus far authentically reported from the Quaternary deposits of eastern United States have come from deposits from the later ice action."

Why should we abstain from reconstructing a picture of the past from the fossils characteristic of a given geological horizon, simply because man must be included? To deny that any record is read aright because man figures in the past with extinct animals is the height of absurdity; and yet, overwhelming as is the evidence, intelligent people still claim a Scotch verdict of "not proven," must, at least, be given. I go, myself, still farther and claim that

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the Delaware Indians witnessed in New Jersey the extinction of the mastodon; evidence to this effect tending to show not so much the very recent destruction of the mastodon in New Jersey, as that the Indian has a very respectable antiquity. With the disposition to modernize everything in connection with the Indian, as is now so popular, I have no patience. To claim that every artistic relic exhumed from the mounds is the handiwork of Europeans, or indicates an association with a superior race, is but a cheap and not creditable method of explaining away the beautiful objects that have been taken from many of these wonderful earthworks.

When my learned friend Dr. Brinton, in addressing this Association, a year ago, remarked, "To me the exceeding diversity of languages in America and the many dialects into which these have split, are cogent proofs of the vast antiquity of the race, an antiquity stretching back tens of thousands of years. Nothing less can explain these multitudinous forms of speech," — I could understand him, thinking as I did, of palæolithic man, and the then even more remote races of the Pacific coast; but when this same author states, as his opinion, "The uncertainty which rests over the age of the structures at Tiahuanaco is scarcely greater than that which still shrouds the origin of the mounds and earthworks of the Ohio and Upper Mississippi valleys. Yet I venture to say that the opinion is steadily gaining ground that these interesting memorials of vanished nations are not older than the mediæval period of European history. The condition of the arts which they reveal indicates a date that we must place among the more recent in American chronology. The simple fact that tobacco and maize were cultivated plants is evidence enough for this," — I am at a loss to discover any valid basis for such a conclusion.

If, as Brinton assumes, the mounds of Ohio were all erected during the past few centuries, what of the "tens of thousands of years" during which the language or languages of the mound-builders was in course of construction and subsequent subdivisions into "multitudinous forms of speech." Is it logical to suppose that, during the immense lapse of time demanded by Dr. Brinton for the formation of languages, these people did nothing, advanced nothing and became capable of building an earthwork only at the very close of an enormously long career? I cannot think it. That there are mounds in Ohio that date far back of any historic tribe of Indians, has, I believe, been fully demonstrated by the cautious and exustive explorations conducted by Professor Putnam and Dr. Metz.

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Let us return to the consideration of early man in New Jersey and to his association with extinct mammals. That careful student of the subject, Rev. Samuel Lockwood, has given us a delightful account of the discovery of a mastodon in an old beaver meadow, and with his conclusions upon the subject, I will dismiss this phase of the question of early man. Says Dr. Lockwood: "Two facts have much impressed me — the great geological antiquity of the mastodons as a race, and the very recent existence of the individual we are discussing. The race began in Miocene time; this individual lived in the Quaternary age, and well up into the soil-making period. . . . Though the race came before those great castors now extinct, this individual was contemporary with the existing beaver, and doubtless with the aboriginal man. . . . It is plain that the mastodon came into what is now New Jersey ere the ice-sheet began. It receded south before it. It followed the thawing northward, and so again possessed the land. It occupied this part of the country when its shore-line was miles farther out to sea than it is to-day. Here it was confronted by the human savage, in whom it found more than its match; for, before this autochthonic Nimrod, Behemoth melted away."

Having made clear, I trust, what is meant by palæolithic man, and shown also, that he *was* a fact and *is* not a fancy, the question naturally arises, What was his fate? Did he, like the mastodon, become extinct, or has he descendants still living on this continent? There is opened here a wide field, but alas! with so few landmarks and these but ill defined, that the student is much in the position of the mariner when under clouded skies and without a compass.

There has been some speculation and a few bold assertions concerning the relationship of *Homo palæolithicus* to existing races, but I am not aware that any statement has been made, wherein the few facts in our possession are claimed to afford conclusive or presumptive evidence. Certainly so far as my own experience goes, the inference I drew from the character of the stone implements does not accord with the crania found in the Trenton gravel. These are not crania of Eskimos, and I had long inclined to the supposition that to these people might be referred the ruder forms of stone weapons, such as we have seen are found in the gravels of the river valley. On the other hand, the three skulls referred to are unques-

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tionably different from those of the known tribes of *Indians* o
Delaware valley.

Rev. B. F. De Costa has, under the title of "The Glacial
in America," published a very thoughtful paper in which he
deavors to show, from historical data, the plausibility of the
that the Eskimo now represents this most ancient of Ameri
races.

This author states that "whatever may be concluded ultima
respecting the antiquity of the Delaware flints, it is quite appa
that the red-man found in America at the period of its redisco
by Cabot, Vespucci, and Columbus, was not the descendant of
glacial man. No line of connection can be made out. This
tinent does not appear to have any Kent's Hole like that at Tor
affording a continuous history, beginning with the cave-bear
ending with 'W. Hodges, of Ireland, 1688,'" and again,"how
man may have reached America, the theory that the Indian peo
sprang from any glacial stock seems untenable. This then, ne
sitates the inquiry respecting the subsequent history of the pr
tive inhabitant; otherwise, what became of him?

That a people corresponding in the main to the supposed gla
man once dwelt as far south as New Jersey has been agreed
various writers, without any reference to the contents of the gla
deposits, of whose existence they did not dream. When, for
stance we turn to the Icelandic Sagas relating to America, it
comes apparent that the Esquimaux once flourished low down u
the Atlantic coast." And yet again, quoting from the same es
we find the statement, "The so-called aboriginal red-man is
paratively a modern, although the author of 'Leaves of Gr
asks concerning 'the friendly and flowing savage,' is he 'wai
for civilization, or past it and mastering it?' However this
be, he is wandering over the graves of peoples who left no re
of their exploits, either in the continent where they sprang into
or where they died. . . . In New England he must have
ceeded the people known as Skrællings. Prior to that time
hunting-grounds lay toward the interior of the continent. In co
of time, however, he came into collision with the ruder peopl
the Atlantic coast, the descendants of an almost amphibious gla
man. Then the coast-dweller, unable to maintain his position
treated toward the far north. The northward movement, howe

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may have been voluntary in part. During long ages passed in the companionship of the glacier, the race must have acquired that taste and fitness for boreal life which clings to the native of the north to-day, and which makes the Greenlander feel that his country is the most beautiful in the world."

Let us see now to what extent these statements of Mr. De Costa are borne out by the traces of early man in New Jersey. Do they or do they not lend probability to them? I have given you the evidence, so far as gathered of strictly palæolithic man, living in the valley of the Delaware during the last epoch of cold. It consists mainly of the rudest known forms of large stone implements, made of argillite of flinty hardness and breaking with a conchoidal fracture. Its peculiarities as a mineral have already been stated, based upon its examination by Mr. Wadsworth. Now it happens that just as the occurrence of surface quartz veins, near Little Falls in Minnesota, proved the first available locality for that rock, so desirable for making implements, as the ice-sheet withdrew; so, in the Delaware valley, a few miles north of Trenton, argillite occurs in place and likewise offered the first available mineral for effective implements other than pebbles, and these were largely covered with water and not so readily obtained, as at present; while the dry land of that day, the Columbia gravel, contained almost exclusively, in this region, small quartzite pebbles an inch or two in length.

If the palæolithic implements were strictly confined to the gravel deposits, like fossils in the underlying marl-beds, then, as it seems to me, the Eskimo theory would fall, and we could only conclude with Dawkins that "we cannot refer them (*i. e.*, the palæolithic folk) to any branch of the human race now alive;" but, as a matter of fact, there is no such break — no evidence of an hiatus of greater or less duration between palæolithic man and the Indian. The former continued to dwell here until the last pebble of the great gravel deposit had been laid down, and possibly into the soil-making period, but not now, as palæolithic man. Whether the change wrought by the alteration of climate, and its influence on the fauna and flora, had to do with it, or through other influences it was effected, none can tell, but the significant advance to the manufacture of more specialized implements took place; the rude argillite palæolith, the same in form the world over, giving way to spears and other definite forms. The form of the product altered, but the same material, argillite, continued in use. There was no pot-

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tery, no polished stone, little if any attempt at ornamentation; still, when we compare these later objects of argillite with the earlier and original patterns, we see what a tremendous forward stride had been made. Had it aught to do with the acquirement of power of speech? as argued by Mr. Hale, that the "speaking man" is a descendant of the "speechless man" of the River drift. But great as the change is, it is insignificant when compared with the handiwork of the Indian — of his handiwork prior to any European contact.

On what grounds can this dissociation be based? Does mere rudeness in the fashioning indicate a difference of origin? Why may not the spearpoints of argillite be the work of Indians as well as similar objects made of jasper? These are questions invariably asked, and however satisfactory the replies have been to myself, they have not proved so, in all cases, to others.

The fact that these rude spearpoints occur upon the surface of the ground is with many an insuperable objection to any claim to significant antiquity; these objectors forgetting the while that there has been habitable surface soil in this region — New Jersey — for a much longer period, than man's first appearance on earth; even in the Garden of Eden.

Let us consider the two questions to which I have referred.

Does mere rudeness in the fashioning indicate a difference of origin? Of itself, certainly not. There are Indians who still make, or did very recently, implements far ruder than the least finished palæolith; and implements of essentially palæolithic character occur wherever ordinary Indian relics are found, but this neither implies that the Indian was a palæolithic man, or that the oldest of these objects, found in gravel deposits was the handiwork of Indians. So long as this confusion exists, so long will American archæology be an unsolvable problem. The telling fact with reference to these argillite spearpoints is that they are not, in the same sense as jasper arrowheads, surface-found implements. They occur also, and even more abundantly beneath the surface-soil.

The celebrated Swedish naturalist, Peter Kalm, travelled throughout central and southern New Jersey in 1748–'50, and in his description of the country remarks: "We find great woods here, but, when the trees in them have stood a hundred and fifty or a hundred and eighty years, they are either rotting within, or losing their crown, or their wood becomes quite soft, or their roots are no

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longer able to draw in sufficient nourishment, or they die from some other cause. Therefore when storms blow, which sometimes happens here, the trees are broken off either just above the roots or in the middle or at the summit. Several trees are likewise torn out with their roots by the power of the winds. . . . In this manner the old trees die away continually, and are succeeded by a younger generation. Those which are thrown down lie on the ground and putrefy, sooner or later, and by that means increase *the black soil*, into which the leaves are likewise finally changed, which drop abundantly in autumn, are blown about by the winds for some time, but are heaped up and lie on both sides of the trees which are fallen down. It requires several years before a tree is entirely reduced to dust."

This quotation has a direct bearing on that which follows. It is clear that the surface-soil was forming during the occupancy of the country by the Indians. The entire area of the state was covered with a dense forest, which, century after century, was increasing the *black soil* to which Kalm refers. If, now, an opportunity offers to examine a section of virgin soil and underlying strata, as occasionally happens on the bluffs facing the river, the limit in depth of this black soil may be approximately determined.

An average, derived from several such sections, leads me to infer that the depth is not much over one foot, and the proportion of vegetable matter increases as the surface is approached. Of this depth of superficial soil probably not over one-half has been derived from decomposition of vegetable growths. While no positive data are determinable in this matter, beyond the naked fact that rotting trees increase the bulk of top-soil, one archæological fact that we do derive, is that the *flint implements* known as Indian relics belong to this superficial or "black soil," as Kalm terms it. Abundantly are they found on the surface; more sparingly are they found near the surface; more sparingly still the deeper we go; while at the base of this deposit of soil, the *argillite* implements occur in greatest abundance.

Here, then, we have the whole matter in a nut-shell. The two forms were dissociated until by the deforesting of the country and subsequent cultivation of the soil, except in a few instances, they became commingled.

Perhaps the most important discovery bearing upon the question of the descendants of palæolithic man is that of Mr. Hilborne T. Cresson who has found, in the alluvial deposits at Naaman's Creek,

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in Delaware, traces of pile-structures, upon which we may presume that a rude fishing people had erected their houses. A detailed description of these remains and the objects found will be given in due time in the publications of the Peabody Museum, but I may lay stress upon the character of the stone implements dredged from the mud about the piling. At two of the structures or "stations," Mr. Cresson finds only argillite implements, many as rude as some of palæolithic types, and a large number of those long, slender spearpoints to which I have already referred. In a third "station," there is a mixture of these forms with others of quartz, jasper and other silicious mineral, with traces of rude pottery.

These discoveries certainly bear out the suggestion I advanced years ago of an intermediate period of human occupancy of our Atlantic seaboard. Here, on the Delaware river, as Lockwood found in the shellheaps of Keyport, New Jersey, and the surrounding country, occur both jasper and argillite, but not so associated as to demonstrate that both minerals were in use at the same time, or used by the same people at different times. On the contrary, the conclusion reached by every competent investigator has been that implements made of argillite antedate those of jasper; and this single impression of many unbiassed students goes a long way toward proving the essentially correct character of these impressions.

Negative evidence of the soundness of this view is had in the character of the sites of arrowmakers' open-air workshops, or those spots whereon the professional chipper of flint pursued his calling.

In the locality where I have pursued my studies several such sites have been discovered and carefully examined. In no one of these workshop sites has there been found any trace of argillite mingled with the flint-chips that form the characteristic feature of such spots. On the other hand, no similar sites have been discovered, to my knowledge, where argillite was used exclusively. The absence of this mineral cannot be explained on the ground that it was difficult to procure, for such is not the case. It constitutes, in fact, a considerable percentage of the pebbles and bowlders of the drift, from which the Indians gathered their jasper and quartz pebbles for working into implements and weapons.

If the absence of argillite from such heaps of selected stones is explained by the assertion that the Indians had recognized the superiority of jasper, then the belief that argillite was used prior to

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jasper receives tacit assent. If, however, it was the earlier *Indians* who used argillite, and gradually discarded it for the various forms of flint, then we ought to find workshop sites older than the time of *flint* chipping, and others where the two minerals are associated. This, as has been stated, has not been done. Negative evidence this, it is admitted, but when considered in addition to the positive evidence of position in undisturbed soil, it has a value that must not be overlooked. Sufficient positive evidence to clear away *all doubt* in the minds of many, of the presence of an earlier people than the Indian on the Atlantic seaboard of America will probably never be forthcoming; yet, to the minds of candid inquirers, there is a degree of probability in the interpretation of known facts that closely hugs the bounds of certainty.

This briefly covers the range of evidence, first, that palæolithic man did not become extinct; secondly, that his descendants attained to an advanced degree of culture in the land of their forefathers. What then was this people's subsequent career? Were it not for the three skulls, to which reference has been made, we could still maintain that we have their descendants in the Eskimo, and that they were finally driven north, after contact with the Indians, who, as is conceded by all students, migrated hither, at, archæologically considered, a not exceedingly remote period. The Indian traditions assert that they found the region occupied; and for once, at least, we have evidence which confirms tradition.

However others may be impressed by what I have now presented, for myself, as I wander along the pleasant shores of the Delaware river, seeing it but a meagre stream between high banks, in midsummer; or, in winter, swollen and choked with ice, until these are almost hidden, I recall what time this same stream was the mighty channel of glacial floods pouring seaward from the mountains beyond and picture the primitive hunter of that ancient time, armed with but a sharpened stone, in quest of unwary game. And later, when the floods had abated and the waters filled but the channel of to-day, I recall that more skilful folk who with spear and knife captured whatsoever creature their needs demanded, — the earlier and later Chippers of Argillite.

These pass; and the Indian with his jasper, quartz, copper and polished stone looms up, as the others fade away. His history, reaching forward almost to the present, I leave in the hands of others to record.

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PAPERS READ.

AN INTERNATIONAL LANGUAGE. By HORATIO HALE, Clinton, Ont., Can.

THE great inventions of our century, which have brought all civilized nations into such near communion,— the steamship, railway, telegraph, and telephone,—require one essential complement. The closer the intercourse between populations speaking different languages, the more the need of some common medium of communication is felt. The sense of this need is naturally not so strong in America as elsewhere; but every traveller in Europe, every mercantile house with foreign connections, and almost every student of science or art, must experience the embarrassment caused by the variety of languages prevailing in the Old World. Since the era of international exhibitions and congresses for all purposes, scientific, philanthropic, political, and artistic, began, this embarrassment has increased so greatly, that many minds have been turned to the discovery of some means of relief.

The first public manifestation of this sentiment has come from a scientific source, entitled to the highest respect. In January last, the American Philosophical Society, of Philadelphia, adopted by unanimous vote a resolution requesting their President to address a letter to all learned bodies with which the Society is in official relations, and to such other societies and individuals as he might deem proper, "asking their coöperation in perfecting a language for learned and commercial purposes, based on the Aryan vocabulary and grammar in their simplest forms; and to that end proposing an International Congress, the first meeting of which shall be held in London or Paris."

Letters have been issued in accordance with this resolution, and there can be little doubt of a favorable response. The initiative proceeds from the oldest of American learned societies, founded by Franklin nearly a century and a half ago, and numbering on its roll of notable presidents Thomas Jefferson, the most scholarly of American statesmen, and Peter S. Duponceau, the father of American philology. This historical prestige and the very large membership, comprising many of the most eminent scholars in both hemispheres, can hardly fail to ensure a favorable reception of its present proposal. No international jealousy can possibly be aroused by the action of an American society, asking for a meeting in Europe.

The President's letter is accompanied and seconded by an able report from a Committee (Messrs. Brinton, Phillips and Snyder) appointed to consider the subject. The report will be everywhere read with interest,

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though some of the views expressed in it will probably arouse discussion. The Committee maintain that inflections are relics of barbarism, and that an uninflected (or, in scientific phrase "analytic") language is better adapted than an inflected speech for the expression of thought. This view, it seems, was strenuously opposed by other distinguished scholars in the Society, who preferred the more usual opinion that inflected (or "synthetic") languages evince in their framers a higher mental capacity than appears in the uninflected idioms. But all the members, without exception,— whatever might be their views on this purely theoretical point, — agreed in holding that an artificial language, designed to be a medium of communication among persons speaking many different languages, should be made as simple and easy as possible, both in pronunciation and in grammar,— a proposition which seems too plain to call for argument.

The Committee, it appears, was appointed in the first instance " to examine into the scientific value of Volapük,"—the "world-speech," of which so much has been lately heard,— an artificial idiom, constructed about ten years ago by the Rev. Johann Martin Schleyer, a learned priest of Baden.

The Committee found in this invention " something to praise, and much to condemn." In fact, its merits and its defects lie on the surface, and are evident to any one familiar with the structure of language and with the need for which such an invention is required. As a distinguished English philologist, Mr. A. J. Ellis, has well observed, Volapük " presents a schoolboy's ideal grammar, there being only one declension, one conjugation, and no exceptions." Indeed, if the object of the invention were to relieve the much-suffering schoolboy of the troubles caused by the monstrous absurdities in the structure of the European languages,— the preposterous orthography of English and French, the nonsensical gender-systems of the continental tongues, the torment of the irregular verbs in all the languages, —Volapük would be everything that could be desired. But while avoiding this obvious Scylla of irregularity, the inventor has been led by his great linguistic ingenuity to plunge into an equally disastrous Charybdis on the other side,— a fatal whirlpool of philological complexities. At the outset, we are met by a gross and surprising error in his alphabet,—an error so evident that the able American interpreter of his system, Mr. Charles E. Sprague (author of a "Handbook of Volapük"), is obliged frankly to admit it. The inventor is not content with the five "pure vowel sounds,"—the *a*, *e*, *i*, *o*, *u*, as they are heard in German and Spanish,— sounds which are familiar and easy to every speaker of every European language, and which, with fourteen or fifteen equally universal consonants, would afford an abundant supply of euphonious words for the amplest vocabulary. He introduces besides, in frequent use, the three German impure vowels *ä*, *ö*, *ü*, easy to him as a German, but to most speakers of other tongues difficult and perplexing. The first and most elementary rule of an international speech evidently should be that no sound, or combination of sounds, should occur in it which is not common to all the leading commercial languages of our time.

But the reason of the introduction of so many vowels soon makes itself

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apparent. The author had determined to depart altogether from the analytic system of modern European tongues, and to revert to the ancient synthetic structure. He would have inflections of all sorts,—cases, tenses, moods, formative prefixes and suffixes,— every complication which his strong linguistic faculty and that "study of more than fifty languages" which his admiring biographer ascribes to him could suggest. Thus the personal pronouns, I, thou, and he,— in Volapük, *ob*, *ol*, and *om*,— do not, as in most European tongues, stand independently before or after the verb; they are made inflections and suffixes. *Löf*, for example (a word derived from the English verb, and in pronunciation midway between "luff" and "loaf"), is love, and *löfob*, *löfol* and *löfom*, are "I love, thou lovest, he loves." This, we know, was the way in which the Aryan verb was originally constructed,— the *t* in the Latin *amat* and the German *liebt*, and the *s* in the English *loves*, being relics of an ancient personal pronoun. But thousands of years have passed since any consciousness of this derivation survived. Having reopened this primitive and long-forgotten path, the learned inventor proceeds resolutely forward in it. He gives us, in his imperfect tense, the Sanskrit and Greek augment, and employs for his purpose one of his German vowels, *ä*, having a sound approaching that of the *a* in hat; *älöfom* is "he loved." Then he goes beyond his models, and forms his remaining tenses by other vowel augments. The perfect tense is *elöfom*, he has loved; the pluperfect, *ilöfom*, he had loved; the future, *ölöfom*, he will love; the future perfect, *ulöfom*, he will have loved. The passive voice prefixes *p*, and so we get in the future perfect passive, *pulöfom*, he will have been loved. The conditional mood ends in *öv*, and the potential in *ox*; and thus we have *elöfomöv*, he would have loved, and *löfomox*, which a doubting damsel would need for expressing "he may possibly love." Then there is a reflexive form in *ok*, *löfomok*,—he loves himself,— and a frequentative form, made by inserting an *i* after the augment, and indicating a habit of action — *äilöfom*, he was in the habit of loving. Here we begin to discern the real models which the author of this extraordinary composition has followed. The aboriginal American tongues, with their numerous and apt derivative forms, which have charmed Duponceau, Max Müller, Whitney, and many other noted philologists, have naturally attracted so good a philologist as Mr. Schleyer. He goes on to give us their well-known method of word-formation. He takes bits of modifying words, makes prefixes and suffixes of them, and sticks them on the "stem words," in a fashion which would delight an educated Iroquois or an Ojibway. From *smalik*, small, he makes a prefix *sma-*, and joining this to *bed*, which has its English meaning, we get *smabed*, meaning nest. From *gletik*, great, we derive *gle-*, which, added to *zif*, town, gives us *glezif*, great city. From *län*, country, he makes a suffix *-än*, and so we get *Bayän*, Bavaria, and *Kanadän*, Canada.

These specimens show sufficiently the class of languages to which Mr. Schleyer's invention belongs. The Committee of the Philosophical Society incline to rank it with the "agglutinative" tongues of Northern Asia; but it is something more and better than one of these. It is really what philologists style a "polysynthetic" language, of the American class, combining agglutinate and inflective forms in a great number and variety. To say

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this of Mr. Schleyer's work is by no means to decry it, but rather, in a certain sense, to exalt it. Max Müller, after a careful study of the Mohawk language, has declared that the framers "of such a work of art must have been powerful reasoners and accurate classifiers." Professor Whitney places the structure of the Algonkin speech, in its "infinite possibilities of expressiveness," above that of the Greek itself. If any votary of Volapük chooses to claim these praises for that speech and its inventor, there need be no demur to the claim.

But these very merits, in the form in which they are displayed in the Mohawk or the Greek, are utter disqualifications for an international speech. The last species of tongue which an experienced linguist would select as a model for such a speech would be one belonging to the polysynthetic or highly inflected class. In fact, the "ideal form" of an international language would be a language without a single inflection. Such are those curious composite idioms which have sprung up spontaneously in various parts of the world as means of intercourse between persons speaking different and difficult languages,—the *Lingua Franca* in the Mediterranean, the "pidgin English" of the Anglo-Chinese settlements, the "Chinook jargon" of our Northwest Coast. English itself, as the Committee point out, is merely such a *lingua franca* or "jargon," in which the slowly coalescing Saxons and Normans learned to speak together, dropping at least four-fifths of their inflections in the process.

The requisites of an international language, so far as alphabet and grammar are concerned, may be very briefly set forth. The chief commercial languages of the world are the English, French, German, Spanish and Italian, and the proposed speech must be made acceptable and easy to the speakers of all these languages. *Its alphabet must comprise no sounds, and its grammar no inflections, which are not found in every one of these five languages.* This simple and essential rule will reduce the alphabet to the five pure vowels and about fifteen consonants, and the grammar to less than half a dozen inflections, all terminal,—a plural form, a past tense, a present participle, a past participle, and possibly one or two other forms. There would be added four or five rules for the collocation of words,—defining the position of the adjective with regard to the substantive, of the adverb with regard to the verb, and of the verb with regard to its subject and object. The whole grammar of the speech, alphabet and all, would not occupy more than two or three pages of the handbook, and its acquisition by any intelligent person would not require more than an hour or two of application. In fact, the international language will be nearly all vocabulary. The grammar will be merely an infinitesimal adjunct to the dictionary, instead of being, as with Volapük, the main feature of the language.

Volapük is taught in "courses" of lessons. In Vienna, we are assured, seven "parallel courses" have been going on, attended by about 2000 persons. In Paris twenty courses are spoken of. In that city, Kerchoffs has published a "Complete Course of Volapük," supplemented by an "Abridged Grammar of Volapük," and by a smaller "First Elements of Volapük." The latter, by the way, is said to have reached its forty-second edition,—a striking evidence of the need which is felt in Europe of an international

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speech. One writer, Mr. Iwan Iwanowitch, has undertaken to give us "Volapük in Three Lessons;" but he does this, as Mr. Sprague's Handbook shows us, by dropping or slurring over many of its forms. Mr. Sprague, more reasonably, presents us with a series of twenty-eight "exercises." We are told, triumphantly, that apt scholars have learned to read and write the language, with the aid of a dictionary, in a week. A week! Now let us see what will be the method with the International Speech.

A merchant in Philadelphia receives a letter of some fifty words from Moscow, superscribed "International Language." He has never seen or heard a sentence of this new speech, though he has read of it in the papers. He sends his clerk for a handbook, which he finds comprises two or three pages of alphabet and grammar, followed by a dictionary in the usual twofold arrangement, International-English, English-International. He glances at the first pages, and takes in the few brief and simple rules on a single perusal. He sees that he has merely to look out the words of the letter, as they stand alphabetically in the International-English part, and put them together in the prescribed order. Half an hour suffices for this simple operation. The few inflections give him no trouble, for they are precisely of the sort he uses in his own language. In composing his answer he reverses the process, and picks out the words in the English-International part. This, at the first attempt, will be somewhat slower work; but less than three hours from the time he opens the handbook will see the translation and the reply completed. A "course of lessons" for the International Language will be as needless as a course of lessons for the telephone. To learn to speak it will require merely the getting by heart of a certain number of words. The grammar, such as it is, will "come of itself," in the acquisition of a score or two of simple phrases, or in reading two or three pages of the printed language.

Every one can see that if the movement commenced by the Philosophical Society shall result in the production of such a means of communication, it will bring an enormous gain to commerce, to the convenience of travellers, to scientific correspondence, and to the friendly intercourse of nations. The creation of such a speech, and in particular the preparation of its vocabulary and the exact rendering of this vocabulary into the principal languages of Europe, will be a work worthy of the best scholarship and the finest intellects of our time. It is saying little to assert that the successful completion of this work will form a step in the progress of civilization not less important — perhaps in some respects much more important — than the successful completion of the electric telegraph.

THE ARYAN RACE, ITS ORIGIN AND CHARACTER. By HORATIO HALE, Clinton, Ontario, Can.

[ABSTRACT.[1]]

VARIOUS theories in regard to the primitive seat of the Indo-European or Aryan race have been proposed, some ethnologists placing it in Asia and

[1] This paper is published in full in the Popular Science Monthly for March, 1889.

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some in Europe. Many circumstances combine to point to the great Iranic plateau, comprising ancient Persia and Bactria, as the region in which the race first became conspicuous. But every linguistic stock must have had its origin in a single household. There is reason to believe that the first Aryan household had its home at some point in the Deshtistan, or low country of southern Persia, bordering on the Persian Gulf and Indian Ocean. Thence its descendants spread over the Iranic uplands, and finally over Europe, where they conquered and partly absorbed the earlier European populations. The physical and mental traits of the Medo-Persian people, as they are described by historians, may be assumed to represent those of the primitive Aryans. They were a handsome race, tall and well formed, with features of the Greek type. In character they were brave, energetic, and truthful, but cruel, superstitious, servile and unintellectual. Their bravery and their habit of combined action, resulting from their implicit obedience to their rulers, enabled them to overcome the scattered and disunited tribes of Europe, on whom they imposed their language, and their system of hereditary government, the origin of European aristocracy. This, in its nature and essence, was a genuine caste system, previously unknown to those tribes. These pre-Aryan tribes belonged to three distinct races — Semitic in Greece and other southeastern countries, Iberian in the southwest and west, and Uralian in the north and centre of Europe. All these races were higher in mental and moral qualities than the Aryan, and especially in the love of freedom and aptitude for self-government. The modern European populations are of mixed race, but mainly of pre-Aryan lineage. Their capacity for union and their conquering energy are due chiefly to the infusion of Aryan blood, but their finer intellectual and moral qualities come from the pre-Aryan races. These races, during the last three or four centuries, have been gradually regaining their ascendency, and throwing off the debasing system of hereditary government introduced by the Aryan conquerors. To the gradual elimination of the pernicious effects resulting from the conquest of Europe by the cruel, unintellectual, and rank-worshipping Aryan hordes is mainly due the immense advance in freedom, science, and morality made by the European nations in modern times. The opinion of the peculiar excellence of the Aryan languages, in comparison with other idioms, is an error which arose before the principles of comparative philology were well understood. Many languages of other stocks are superior to the primitive Aryan speech in the capacity of expression. The grammar of that speech has many gross defects, indicating a lack of logical power in its framers. The modern Aryan tongues have been gradually working themselves free from these defects.

NOTES ON AMERICAN COMMUNITIES. By ANITA NEWCOMB MCGEE, Washington, D. C.

[ABSTRACT.]

AFTER defining Communism as the doctrine and practice of common ownership of property, and discriminating it from socialism to which it

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is related on the one hand and coöperation which it approaches on the other hand, the author proceeded to describe the seven measurably successful American community systems, setting forth briefly the causes which led to their establishment, their social, moral and political attitude, their growth, and the circumstances which led to the dissolution of those no longer existing. Special attention was given to the history of American communities within the last twelve years, during which period the subject has not been comprehensively treated by any writer.

Several communities were visited during the past year by the author, and information concerning others was obtained by correspondence with former and present leaders. They are as follows: 1. The German Inspirationist Community of Amana, in eastern Iowa, now in a flourishing condition; 2. The system of communities of the celibate Shakers in the eastern United States; 3. The German Community at Zoar, in eastern Ohio; 4. The German Harmonist (or Rappist) celibate Community at Economy, in western Pennsylvania; 5. The remnant of the French Community at Icara, in southwestern Iowa; 6. The American Perfectionist Community at Oneida, New York, extinct since 1880; and 7. The Bethel Aurora-Community in Missouri and Oregon, dissolved in 1878. Each of these lasted at least thirty years, but only the first is still increasing in membership.

It was pointed out that the characteristic which distinguishes the successful from the numerous unsuccessful and short-lived communities, is that the former labored under great difficulty and often persecution at their beginning and have since been cautious in the admission of new members.

Finally, the author discussed briefly the desirability of community life and the conditions of stability of community organization, and concluded *first*, that community life is acceptable only to individuals of unusual tastes and ideas; and *second* that, partly for this reason and partly because it antagonizes the family relation and runs counter to the tendency of social evolution, community organization is necessarily unstable and evanescent.

Early Man in Spain. By Dr. D. G. Brinton, Media, Pa.

[ABSTRACT.]

The Iberian peninsula presents points of especial interest to the general anthropologist and also to the Americanist. It is alleged that the most ancient remains of a man-like animal in Europe have been found there, and the affinities of the Basque language with American tongues have been a frequent subject of comment.

These oldest remains belong to the lower Miocene, and, if authentic, would show that at that early epoch, an animal who chipped flints into tools lived on the western shores of the peninsula. Palæoliths of the Chellean type have been found on the slopes of the Sierra Nevada, in caves of the Cantabrian mountains, and in early quaternary river-detritus near Madrid.

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An examination of the last mentioned beds proves that a
their deposit a large river was flowing in that locality fron
This is one of many evidences to prove that at the close
and probably long after, an extensive land-area occupied t
tic and connected the Iberian peninsula with North Ameri
able that this was the land-bridge used by the first men who
to the American continent.

Neolithic stone implements are not infrequent in Spa
striking analogies of appearance with those from northe
The megalithic rock-structures, especially those in Portuga
from Neolithic times.

The Basques are a pure branch of the white race, who
over the whole of the peninsula, but are now confined to th
Pyrenees. Their language has many structural analogies t

TRAITS OF PRIMITIVE SPEECH, ILLUSTRATED FROM AMERIC

By Dr. D. G. BRINTON, Media, Pa.

[ABSTRACT.]

THE earliest intelligent utterances of man were undoubte
than any language now spoken. What they must have bee
tained to some extent by a study of the simplest existing
American languages offer exceptionally favorable materi
they have been so isolated that they retain their primitive t
netics of these tongues indicate great variability combine
significance. Both vowels and consonants have fixed me
to them, but are permutable under certain vocal laws. The
Cree offer numerous examples of both these peculiarities.
consonantal sounds are double, or, as we should express
the alphabet can not be used without another pronounce
the Tupi cannot utter the sound of *b* without preceding it
of *m*. There does not appear, however, to be a fixed re
sound and sense in these primitive utterances.

Many of the radicals, both phonetic and syllabic, mean b
its opposite. The explanation of this is that according to
as the second law of thought an idea is defined by an equa
both the idea and its privative, as a = not not — a. In a
primitive speech included under the same sound both the
privative of the idea.

The most marked characteristic of the grammar of th
their effort to express the whole proposition in one word by
incorporation. This is believed to be universal in American
word-sentences were disconnected, and even yet there is no

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machinery in these tongues to display the relation of the leading and dependent clauses; relative pronouns and conjunctions are unknown.

Many ideas can be expressed only in relation, as an active verb and its object, the parts of the body, consanguinity, etc. Numerals in primitive speech were unknown, as were also grammatical gender and case. Early man appears to have been a visuaire rather than an auditaire, and his main distinction of things was into living and not-living, or animate and inanimate.

ON THE ALLEGED MONGOLOID AFFINITIES OF THE AMERICAN RACE. By Dr. D. G. BRINTON, Media, Pa.

[ABSTRACT.]

MANY writers have asserted that the American race presents various racial traits of the Mongolians, and hence have classed the Americans with the Mongolians or applied to them the term "Mongoloid."

These alleged affinities may be examined either as of language, of culture, or of anatomical peculiarities.

The Mongolian people, taken broadly, speak either monosyllabic and isolating, or polysyllabic and agglutinating languages. The Eskimo has been asserted to resemble the latter, the Otomi the former; but a moderate examination proves the supposed analogies to be remote and insignificant.

In culture there are many parallelisms, but nothing which would justify a belief that the one civilization sprang from or was materially influenced by the other.

The anatomical analogies which have been adduced refer to the color of the skin, the hair, the shape of the skull and the oblique eye; all these, on examination, prove delusive, while some other traits, as the nasal index, are decidedly un-Mongolian. It is also true that those tribes, once said to be peculiarly Chinese-looking, have not proved so on closer examination.

A LIMONITE HUMAN VERTEBRA FROM FLORIDA. By DR. D. G. BRINTON, Media, Pa.

[ABSTRACT.]

A HUMAN vertebra from a postpliocene deposit in Florida, the calcareous tissue completely removed and replaced by hydrated peroxide of iron.

NOTE ON CERTAIN PREHISTORIC ORNAMENTS FOUND IN MISSISSIPPI. By Prof. R. B. FULTON, University of Mississippi.

[ABSTRACT.]

EXHIBITION of certain ornaments of a hard jade-like, but reddish material, found near Wesson, Mississippi, about sixty miles east of Natchez.

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THE DEVELOPMENT OF THE CIVILIZATION OF NORTHWEST AMERICA. By Dr. F. BOAS, New York, N. Y.

[ABSTRACT.]

THE civilization of Northwest America is not uniform, but three centres may be distinguished which agree fairly with the linguistic divisions: the Tlingit, Tsimshian, Kwakiutl and Salish. Totemism of these groups; their mythologies; their social organization. It is possible to trace the influence of the Kwakiutl upon their neighbors and to show that they have had a material influence upon the civilization of Northwest America. Discussion of their dances. The use of cedar-bark ornaments. The cannibalism is connected with their dances. The Tsimshian, Haida and Nutka adopted these customs from the Kwakiutl. Linguistic and historical proofs of the fact. Probable origin of the use of masks and heraldic columns. The development of arts among the Haida.

Alleged similarity of Asiatic and Northwest coast culture. A similarity of the Kwakiutl, Salish and Tsimshian elements out of the question. It is necessary to study the Haida element and it may be that here a connection exists.

RECENTLY DISCOVERED ALGONKIN PICTOGRAPHS. By Col. GARRICK MALLERY, Bureau of Ethnology, Washington, D. C.

[ABSTRACT.]

DISCUSSION of the publications of Henry R. Schoolcraft, issued in 1853, upon the pictographs of the Ojibwa, giving the impression that they were nearly as far advanced in hieroglyphic writing as the Egyptians before their pictorial representations had become syllabic. Doubts of the accuracy of these accounts had been entertained, hence an expedition was made last summer by Col. Mallery and Dr. Hoffman to five reservations in Minnesota and Wisconsin to learn what might remain on the subject, resulting in obtaining a large number of bark records old and new, showing great pictographic skill and its general use in ordinary affairs of life as well as religious and ceremonial, though Schoolcraft had colored and exaggerated.

Account of an expedition by Colonel Mallery to Maine, New Brunswick, Cape Breton and Prince Edwards Islands and Nova Scotia to investigate the bark records and petroglyphs of the Micmacs and Abnaki, with special attention to the aboriginal nature of the characters first used by French missionaries in 1652, and afterwards published by Father Kauder in 1862, commonly called the "Micmac Hieroglyphics." An important and unique body of rock etchings was discovered at Kejemkoojic Lake in Nova Scotia and petroglyphs near Machias, Maine, also a variety of bark records and traditions relating to them.

Copies of about one hundred of the pictographs, some of original size, and some enlarged so as to be visible, were hung on the walls as illustrations of the paper.

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THE ONONDAGAS OF TO-DAY. By Rev. W. M. BEAUCHAMP, Baldwinsville, N. Y.

[ABSTRACT.]

THE Onondagas have almost forgotten their past history. In the past half century there has been a gradual improvement in their condition, but it does not yet rank high. Social and political changes are continuous in the clans and in the government of the nation. There is much mixed blood, though less than is supposed. The white dog-feast is now kept without the dog, and there are changes in other feasts. The False Faces maintain some early customs, and form a society. A recent condolence at Onondaga showed old usages, but in a modified form. It was conducted by the Oneidas. Some early kinds of cookery are retained as well as early implements and articles of furniture. Many superstitions remain, but all are not such which have this appearance. The dead feast and the driving off of witches are the most important. Strings of wampum, differing in color, size and number are used in many ceremonies, and were briefly described. They have been partial to silver ornaments, but these have mostly disappeared, and those shown are fair samples of the remaining forms. Changes of life and environment are rapidly affecting the language, as new words have to be formed and old ones abandoned.

THE RARER INDIAN RELICS OF CENTRAL NEW YORK. By Rev. W. M. BEAUCHAMP, Baldwinsville, N. Y.

[ABSTRACT.]

THE grooved boulders of Onondaga and Yates counties are remarkable the grooves being from eight to twenty inches long, and about three-fourths of an inch deep and wide. They are of the early historic period. Other curious relics are the polished slate arrows, some forms of flint implements, stone cups, stone and clay tubes. Some peculiarities may be seen in pipes of different eras, and there are noteworthy differences in copper implements, beads, scrapers, drills and earthenware.

UNFINISHED "BANNER STONES" FROM THE SUSQUEHANNA RIVER. By ATREUS WANNER, York, Pa.

[ABSTRACT.[1]]

IN this paper were described a number of unfinished "banner stones" from a limited region along the Susquehanna river. The specimens were so grouped as to illustrate successive stages in their manufacture.

As determined by the specimens presented, the process of making banner stones consisted in: first, roughly flaking and pecking into shape; second, grinding; third, drilling the hole.

In conclusion the author gave as his opinion that a hafted implement, with a sharp point, was used in pecking the various specimens described.

[1]This paper will be published in the "American Naturalist."

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THE PSYCHOLOGY OF DECEPTION. By Prof. JOSEPH JASTROW, Ma
Wis.

[ABSTRACT.]

A FUNDAMENTAL distinction necessary to understand how decept
carried on is that between what is given and what is inferred in perce
We confuse the two as well as make inferences unconsciously.

A perception depends as well upon the nature of the percipient as
the object perceived. We interpret the unknown by the known
type of deception occurs when this general rule does not hold good.
other type of deception depends upon subjective causes, the misplaci
attention, lapses of memory, a dominant idea, prejudice and so on.
juring and the physical manifestations of spiritualism furnish the mo
illustrations of the process.

SOME OF THE CHARACTERISTICS OF THE YAKUTAT INDIANS OF AL
By Prof. WILLIAM LIBBEY, JR., Princeton, N. J.

[ABSTRACT.]

DISCUSSED briefly the physical characteristics of these Indians
notes made on a trip among them in 1886.

SOME ANCIENT DIGGINGS IN NEBRASKA. By Prof. J. E. TODD, Tabo

[ABSTRACT.]

THIS paper gave a description of an ancient quarry, many square
in extent, which is on the farm of Mr. Isaac Pollard, near Nehawka,
Co., Neb. It is clearly the work of aborigines. Oak trees, thirte
seventeen inches in diameter, grow over it. The object of search
to have been masses of flint in a layer of carboniferous limestone.
comparable with the famous pipestone quarry of Minnesota, both i
tent and depth of excavation.

ON SOME RECENTLY CHIPPED ARROW-POINTS FROM NORTH CAROLINA.
GEO. F. KUNZ, New York, N. Y.

THE SERPENT MOUND AND ITS SURROUNDINGS (illustrated by la
views). By Prof. F. W. PUTNAM, Peabody Museum, Cambridge, M

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ON ANCIENT ARROWS AND A NEW METHOD OF ARROW RELEASE. By Prof. EDW. S. MORSE, Salem, Mass.

PALÆOLITHIC IMPLEMENTS FROM THE GRAVEL, NEWCASTLE CO., DELAWARE. By HILBORNE T. CRESSON, Philadelphia, Pa. [Presented by Prof. F. W. Putnam. Printed in Proc. Boston Soc. Nat. Hist., Vol. XXIV, 1889.]

CHIPPED IMPLEMENT FROM THE GRAVEL ON THE EAST FORK OF WHITE RIVER, JACKSON CO., INDIANA. By HILBORNE T. CRESSON, Philadelphia, Pa. [Presented by Prof. F. W. Putnam. Printed in Proc. Boston Soc. Nat. Hist., Vol. XXIV, 1889.]

EXHIBITION OF COPPER AND STONE IMPLEMENTS. By WALTER C. WYMAN, Chicago, Ill.

IOWA MOUND-BUILDERS' RELICS. By JOEL W. SMITH, Charles City, Iowa.

WOMAN'S SHARE IN PRIMITIVE INDUSTRY (with lantern illustrations). By Prof. O. T. MASON, Washington, D. C. [Printed in American Antiquarian, 1889.]

MAN DURING THE PALÆOLITHIC PERIOD IN AMERICA. By THOMAS WILSON, Washington, D. C.

ON A REMARKABLE GOLD ORNAMENT FROM THE UNITED STATES OF COLUMBIA. By GEO. F. KUNZ, New York, N. Y.

A REMARKABLE JADEITE TABLET FROM SANTA LUCIA COTZULMALGUAYRA, GUATEMALA. By GEO. F. KUNZ, N. Y.

SOME NEW GROUPS OF EFFIGY MOUNDS: THEIR LOCATION AND SIGNIFICANCE. By Dr. STEPHEN D. PEET, Mendon, Ill.

THE CLAN SYSTEM AMONG THE MOUND BUILDERS. By Dr. STEPHEN D. PEET, Mendon, Ill.

DID THE CHEROKEES BUILD THE SO-CALLED VILLAGE ENCLOSURES OF THE SCIOTO VALLEY? By Dr. STEPHEN D. PEET, Mendon, Ill.

THE MOUNDS IN THE MISSISSIPPI BOTTOM LANDS AS PLACES OF REFUGE FROM HIGH WATER. By Dr. STEPHEN D. PEET, Mendon, Ill.

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SECTION I.

CONOMIC SCIENCE AND STATISTICS.

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ADDRESS

BY

CHARLES W. SMILEY,

VICE PRESIDENT, SECTION I.

ALTRUISM CONSIDERED ECONOMICALLY.

THE primary motive of human action has always been the care of self, this being for man nature's first and greatest law. In his unthinking zeal he has often followed this to a degree unnecessary and consequently harmful to others. In his savage state and especially in his primeval condition, where he was subject, like all the lower forms of life, to the law of the survival of the fittest, he could not consider others' interests because they were so antagonistic to his own. Often one of two must starve, and each would let it be the other one; he did not even become conscious that he was so acting for a very long period of time. It was the progress from a being not human to the being called man when sufficient intelligence had accumulated to make him conscious that he could live and let live. That point was also marked by and synchronous with the acquirement of such weapons and such skill as enabled man to procure food enough to make the starvation of some unnecessary. Then the war for the survival of the fittest, as known to biology, ceased among men. Ever since, so far as there has been a struggle affecting the survival of the fittest, and that struggle continues to the present day in certain ways, it has been of a different sort and one which must not be confounded with the biologic law of the survival of the fittest. Major Powell has admirably shown how the strictly biologic struggle has ceased in man but he has not yet shown, as may be, the character of that struggle, largely intellectual, which still works out certain survivals of the fittest.

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Having passed from the point where, if he survive, it must be at the expense of others, man began to recognize and to consider the desires of his fellows, and among others he counted not only his fellows but mythical and supernatural beings. Thus appeared the greatest natural basis of religion. It is not strange, therefore, that religion should have existed from very early times and that it should have taught its votaries especially to regard the needs of others. Its mission was to teach a race whose ancestors had been absorbed for untold ages in caring only for self, to adapt itself to a new environment by learning to care for the wants of others. In caring for others the more powerful soon received superior recognition, so it came to pass that supernatural demands took precedence of the rest. When that point had become clear, men were easily tempted to profess to represent the gods in order that they might share the precedence. In this natural way became established the order of duty which was taught by every religion prior to Christianity, viz.:

1. To the gods and their representatives.
2. To self.
3. To others.

Early Christianity must be credited with changing the order of duty to the following:

1. To its one supernatural being.
2. To all others equally with self.

Even under this improved system, many people are led to make great personal sacrifices in the belief that thereby they are living the noblest life possible to man; when, in reality, as it is the object of this paper to show, their sacrifices are either useless or what is worse, grossly injurious both to themselves and to the supposed beneficiaries.

SELF-INTEREST AND SELFISHNESS.

During all the untold years in which it was a physical necessity to regard self even to the injury of others, our ancestors acquired a predisposition thereto which heredity has brought down the stream of time. As being no longer a necessity, its practice long since became one of the recognized evils of the world. We apply to it the opprobrious epithet of selfishness. There is a better term and one which does not imply a moral quality, for there may be devotion to one's own interests which should not be so characterized.

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Egoism is such devotion to one's own interests; it may be proper and it may be improper. The term does not imply either propriety or impropriety. Let the word self-interest stand for justifiable egoism and the word selfishness represent unjustifiable egoism.

Egoism then was once a necessity, and while it was a condition to existence, it was justifiable, whatever its effects on others might have been. When things changed so as not to render egoism a necessity, man was still as prone to practise it as before. He was acting under the acquired impulses of ages. It was an extremely difficult thing for him to repress his egoism; it was perhaps even more difficult for him to understand that he ought to do so. And yet the change of circumstances had produced a change in its moral quality. From the practice of self-interest he had passed to the practice of selfishness and he had so passed unconsciously, for the change was in environment and not in him. The same act that had been a virtue was now a vice. Of course centuries were needed for this idea to develop and to be disseminated, but at length it came. Although the terms were not in use, the differentiation had taken place. The terms came when needed to express existing ideas.

ALTRUISM.

Long after egoism had differentiated into self-interest and selfishness came the idea of doing something for others. Man's powers were then so limited that this was not much. Even when he became capable he was slow to discover it and slower to act upon it. Heredity bound him. To loosen him was the mission of religion. Whatever its votaries may claim as to its history and purpose, the one great and overwhelming power that religion has had upon the world is this — it has developed doing for others. It has turned man's attention away from himself to those not himself. A most excellent term to use for this is *Altruism*,— a term first employed only about fifty years ago by Auguste Comte to signify devotion to others or to humanity. Percy Smith, in his "Glossary of Terms and Phrases," defines it as "the doing to another as one would be done by; opposed to egoism."

Such terms as benevolence and charity have been generally used to cover the idea of altruism, but in the mind of every one benevolence and charity involve the moral quality of goodness. It is of the greatest importance to have a word like altruism which does not imply any moral quality and which covers all we do for

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others regardless of the consequences, just as egoism covers all we do for self regardless of consequences or of moral quality.

ALTRUISM THUS FAR INDISCRIMINATE.

That mankind has thus far regarded all altruism as good is undeniably shown by the fact that neither English nor any other language has words to distinguish proper from improper altruism. This distinction has not been well developed. It was early seen that the motives were of importance. If we do something for others it should be with a good motive. The act was declared to be of no subjective value unless the motive was lofty, thus: "Do not your alms before men to be seen of them, otherwise you have no reward of your Father which is in Heaven." Calling attention thus to motives was doubtless a great advance upon the preceding times. This improved form of altruism was, however, indiscriminate. Nothing was said nor implied, in the above precept, as to the character of the persons to whom alms were to be given. Nothing was hinted nor thought of the ultimate effect upon the recipient of giving alms, much less of taking steps to prevent any needing alms. Elsewhere the intimation was that all who were poor should receive, as indicated by the direction "Go and sell all that thou hast, and give to the poor, and come and follow me and thou shalt have treasure in heaven." "He that giveth to the poor lendeth to the Lord." "It is easier for a camel to go through the eye of a needle, than for a rich man to enter into the kingdom of God." Here the extreme of altruism was proposed, but utterly without discrimination as to the objective effect.

NECESSITY OF LIMITING THE MEANING OF ALTRUISM.

Just as all people assume the moral character of benevolence and charity, so there is a disposition to assume that all altruism is good, in other words to use it as a synonym. Some writers of much prominence have not properly treated the subject of altruism, and religious writers especially fail to measure its true character; that is, we see forms of altruism held up as the *summum bonum*, its teachings are said to be almost or quite divine. A professor in Johns Hopkins University has recently in the Congregationalist spoken of altruism as the opposite of selfishness which latter term he also confounds with egoism (and spells it egotism). This is very unfortunate. We shall never work out social problems with such con-

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fusion of ideas. Seeing men in such positions treat altruism as always a good thing and seeing them urge its practice without consideration or without limitation has prompted this attempt to distinguish between justifiable altruism and unjustifiable altruism as carefully as moralists distinguish between justifiable egoism (self-love or self-interest) and unjustifiable egoism (selfishness). And right here the moral philosophers must be alluded to. They have been so zealous to destroy selfishness that they have urged the doing of good to others without sufficiently distinguishing between seeming good and the evil effects thereof. They have too much determined the quality of acts by an examination of the motives under which the acts were performed and too little by an examination of the effects produced. They ought long since to have studied the character of altruism.

THE GOOD ACCOMPLISHED BY INDISCRIMINATE ALTRUISM.

For 1,800 years the world has had an altruism which failed to discriminate as to the object, and, as will appear later, altruism has often been carried to injurious excess, and yet we have had about as good general results as could be expected under the circumstances. The early step from justifiable egoism to that which discriminated was a long one. From the mind resting on self to considering the immediate wants of others was a great advance. From altruism performed with selfish motives to disinterested benevolence was another grand advance. The order of human progress doubtless required a long discipline in indiscriminate altruism before men should learn to differentiate it by observing its results. Again, not only man's mental progress but that of life on the earth has been by pendulum beats from extreme to extreme, by action and reaction, until finally the golden mean of Horace has been reached. The shield was neither silver as protested by him who viewed it from the east nor yet gold as viewed by him in the west; but, had not each held and proclaimed his opinion, the truth would not have been reached by either. Progress limps and goes by indirections; but the various steps indicated have been taken and well taken.

To Christianity then, by far the greatest exponent of this indiscriminate altruism, is due the great credit of having taught it and measurably brought the world from selfishness to disinterested benevolence. It matters not that the race might have traversed this path under some other banner, and that many tribes have found

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it independently. "Honor to whom honor" permits this willing recognition. Although it overlooked this newer feature it had enough to do for man of a more primary character.

NON-RESISTANCE AND SELF-ABNEGATION ALTRUISTIC.

The most intense manifestation of the altruistic spirit is in non-resistance to evil and in utter disregard of self. How beautiful seem to us those precepts pointing thereto.

"Whosoever shall smite thee on thy right cheek turn to him the other also. If any man sue thee at the law and take away thy coat, let him have thy cloak also. Lay not up for yourselves treasures upon earth where moth and rust doth corrupt and where thieves break through and steal. Take no thought for your life, what ye shall eat or what ye shall drink nor yet for your body what ye shall put on. Consider the lilies of the field, how they grow; they toil not, neither do they spin, and yet I say unto you that Solomon in all his glory was not arrayed like one of these. Take therefore no thought for the morrow for the morrow shall take thought for the things of itself. Give to him that asketh thee and from him that would borrow of thee turn not thou away. Go and sell all that thou hast and give to the poor and come and follow me and thou shalt have treasure in heaven."

WHY NON-RESISTANCE AND SELF-ABNEGATION ARE BUT LITTLE PRACTISED.

And yet however grandly its maxims may ring in our ears, whatever praises we may bestow upon its advocates and whatever satisfaction we may express with the past, the day for this indiscriminate altruism has gone by and we are confronted with present duty. To-day the only man who sells all that he has and gives to the poor is the unfortunate one whom we shut up in the insane asylum. To-day the only one who takes no thought for the morrow is the tramp or the beggar. (The professional beggar has even sense enough to keep a bank account.) Those extremes of altruism, non-resistance and self-abnegation, have been discarded. And why? Let us now recognize the virtue in them and understand also just why they are impracticable.

The virtue of those precepts lies in their power to draw men away from self. Read them slowly—not a selfish motive to be found in them. They remove one the farthest possible from thought of self-

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At the time when the degradation of women was greatest, when chattel slavery was so universal that even St. Paul returned a runaway to his master, when political freedom was unknown, when drunkenness and debauchery far exceeded the present, the best thing for mankind was to hold up this extreme of altruism as an ideal and even to declare it divine, which it nearly was in comparison with the evils combatted. So long as no one could point out its defects, its force would be and was very great for good. Through the self-inflicted injuries which the early Christians caused in practising these principles was the tide of human selfishness checked. But the evil of these precepts consisted in their subjective influence being excessive (therefore injurious) and in their utter disregard of ultimate and objective results. He who curbs his own selfish and grasping spirit by taking no thought for the morrow lays himself liable to want (which is perhaps the lesser of the two subjective evils), but the objective effect is more far-reaching and only evil. It acts as an incentive to others to idleness, improvidence and ultimate beggary. He who being smitten on one cheek turns the other cultivates patience and self-control, but he leaves his assailant all the more ready to smite the next man he gets mad with. Again, the subjective effect has good in it; the objective effect has far-reaching evil in it. If I imitate the lilies of the field which neither toil to make themselves a shelter nor spin themselves clothes, I may be admired for my assurance and freedom from anxiety, but I shall also be cut down by the first frost of adversity and be ruthlessly swept out of sight by the first snow of winter. Objectively, I shall have set a bad example to weaker minds than mine. They will say "Let us eat, drink and be merry, for to-morrow we die." And the world will have paid dearly for my little exhibition of self-culture.

He, who, sued at law for a coat by a grasping neighbor, peacefully folds in a cloak also, may cultivate some useful feelings in his own breast while inflicting an unwise deprivation upon himself, but the victorious plaintiff has become a meaner man and will bring new suits at the earliest opportunity; if not upon this, upon some other man whom he thinks he can browbeat, and there are plenty of lawyers who will help him to do so. He, who sells all he has and gives to the poor, may, if he is very badly eaten up with greed for money, discipline himself in the right direction, but in selling *all* he has deprived himself of the means of self-support in sickness and endangered the care of his family. But all this of subjective

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wrong might be perpetrated to curb a grasping spirit through the loss of property. That, however, which he had no right to do, he has done. He has pauperized the poor. The evil inflicted upon scores and perhaps hundreds is in their lessening of self-respect, the cultivation of indolence, the enfeebling of their already weak determinations, the putting farther away of that day when the poor shall be properly paid for their work, and the fostering of that reckless spirit "the world owes me a living and I am going to have it." If the next rich man does not sell out and distribute soon enough they will thirst for his riches,—perhaps for his blood. If some of his wealth is ill-gotten, as is the case with many rich men, they will consider it all so. In such soil the seeds of communism grow. The advocates of anarchy and the haters of government are found always among the poor.

Now note this most remarkable fact,— that every single precept pointing to non-resistance and self-abnegation while subjectively attractive, ignores the objective and ultimate effect; that is, they all seem to be of benefit to the doer but make not an iota of discrimination as to the effect upon others; while, in fact, as history has shown, and as we are now beginning to know, both are injured; but the greatest harm is done to the supposed beneficiaries.

Self-abnegation is thus as far from virtue as selfishness. The golden mean lies between, where our egoism benefits us but does not sting another and where our altruism benefits others in its ultimate effects without sapping their or our own welfare. Selfishness is shortsighted gratification of base impulses. Self-abnegation is short-sighted gratification of benevolent impulses. Both are impulsive, both are shortsighted and both inflict evil upon others.

CHARITY AND BENEVOLENCE.

A more moderate and acceptable form of altruism goes under these names. They are also valuable in curbing the spirit of egoism and have made many people, both givers and recipients, happy for the time being. "To do good and to distribute forget not, for with such offerings the Lord is well pleased." Again no discrimination is made as to the objects of charity and of benevolence, nor as to the remote and real effects of such action. It seems to have been thus far assumed that no discrimination need be made. The exhortations to charity and benevolence never specify the objects minutely, while in fact, this should be the all-important feat-

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ure. In seeming prohibition to any suggestion of discrimination we are told that benevolence should be universal because the Creator "maketh His sun to rise upon the evil and upon the good, and sendeth rain upon the just and upon the unjust." Now in the case of sunshine and rain it would be physically impossible to discriminate. It should also be remembered that the same Creator for the same reason sendeth the lightning and the earthquake to destroy both the just and the unjust. But, what is more to the present purpose, he starves to death those who in summer fail to lay by a supply of food for the winter; He smites with disease those who are too lazy to cultivate cleanliness; and He visits the iniquities of fathers upon *thoughtless* children to the third and fourth generation. Here is a lesson in discrimination of cause and effect not to be overshadowed by a few platitudes about rain.

THE ECONOMIC PHASES OF THE SUBJECT.

But we must turn to consider the economic effects of altruism by means of which we are to distinguish justifiable altruism from unjustifiable altruism. So much of description has been necessitated by the newness of the subject, and even now it is to be feared that those who have never discriminated as to doing good to others, except as regards the purity of motive in the doer, will feel more concerned about the integrity of the precepts that have been dissected than about the analysis of truth. Be that as it may, and it would be a matter of regret to offend the ancient prejudices of any, it is to be hoped that the economic remarks to follow will but substantiate and illustrate the principles already laid down.

Now that we have reached the study of social, political and economic science, we are called upon to analyze the subject, to define our terms carefully, to be sure that we build our sciences on facts, and to state our conclusions clearly. And our conclusions are most hopeful. They are that in doing real and not seeming good to ourselves we also benefit the race; that in doing good to others it is not necessary nor wise that we inflict sore deprivation or indignity upon ourselves; that thrift and wisdom consist in taking a reasonable thought for the morrow; and that in nothing so much should we take anxious thought for the morrow as when appealed to for alms or to assist the needy.

Better that they suffer hunger to-day and be made self-respecting and self-supporting to-morrow, than that they be fed to-day

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and then be forgotten to-morrow. We best help others by securing them full justice and by refraining from injuring them either through malice or through giving them that for which they return no equivalent.

I. RELIEF OF THE POOR.

This class does not include the sick, the dependent children nor the insane, but simply those who are more or less of the time idle, who receive but small wages when they work, and who ask, or do not ask but seem to need, financial assistance.

So many have been willing to lend to the Lord (*i. e.*, give to the poor) believing that it was a safe and dividend-paying investment, that for eighteen hundred years this has been the usual mode of relief.

Everybody knows that this has not diminished the number. It was very unfortunately said eighteen hundred years ago, "the poor we have always with us," because the saying of it has helped to make it true. Assuming that we are to have the poor always with us, we shall do little to lessen their number. Had it been said upon the same authority "under the beneficent sway of wisdom the poor shall cease to exist among you," as it was said "the wolf and the lamb shall lie down together," by this time we should have been far nearer the realization.

Early Athens—pagan Athens, if you choose, could boast of having no citizen in want, "nor" says the Grecian historian "did any disgrace the nation by begging." This should have been our motto. With all the resources of this nation, its realization would have been easy had the proper course been pursued. In such a country as ours it is not necessary, but it is a shame and disgrace to have the the poor always with us,—that is, poverty which needs relief. In the presence of millionaires, men owning but a single cottage are poor by comparison. We ought always to have such poor among us but these are self-respecting and happy men. They must never be confounded with those who through defective character sometimes require food, coal or shelter to be provided for them. The latter are intended when allusion is made to the poor.

Now, if anything of social and economic value has been demonstrated in this century, it is that giving food, coal and money to the poor from public funds or even by private charities pauperizes and degrades them. Henry George says that "the poor are growing

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poorer." If so, to nothing is it more attributable than to the multiplication of charities. "A city of charities and a city of paupers" is the designation of one of our eastern municipalities.

CAUSE OF PAUPERISM.

How charity becomes the cause of pauperism may easily be understood. The problem has been well worked out especially in England. Henry Fawcett, professor of political economy in the University of Cambridge, in "Pauperism: its causes and remedies," published 1871, says: "those get the largest share of charity—not who suffer most—but who can excite the greatest sympathy. Hence securing charity becomes an art; begging, a profession. Hypocrisy and lies are the principal tools. Those who acquire skill in it frequently obtain greater incomes than those who labor."

A case in Washington, D. C., illustrates this.[1] In August, 1885, a boy of about fourteen years was found regularly begging on Pennsylvania avenue. His mother, healthy and reasonably intelligent, lived in a neat house on a pretty street within three blocks of the capitol. There was no sign of poverty nor of distress about the house, inside or out. The boy had during the sessions of Congress sold papers at the capitol reaping a rich harvest. He limped about with a crutch. People gave him five, ten, or twenty-five cents for a paper and asked no change. When Congress adjourned he could still have supported himself well by selling papers on Pennsylvania avenue; but people there did not pay over five cents for papers as a rule. Still they did give to beggars, especially to those with crutches. It easily appeared that the boy could make more money by begging than by selling papers and so he begged. Even after he had been taken into police court twice he returned to the street to beg. It was only with great difficulty that the writer succeeded in stopping this imposition upon the public,—the sweet, confiding public which is ever seeking to give to strangers because "some have thereby entertained angels unawares." Yes, a public which is too lazy to investigate the effects of its alms-giving and which deserves to be imposed upon.

Now let no one express horror at the character disclosed in this child or rather in his mother who was the real actor. She was no better and no worse than the average citizen. She simply exer-

[1] I made the investigation of it in person and prosecuted it in the police court before Judge W. B. Snell.

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cised business sagacity in getting money apart from moral considerations. So do Wall street brokers; so do many men who endow colleges, build churches and send missionaries to "the heathen."

THE CURE OF BEGGING.

The solution of this economic problem is of the simplest. Make begging unprofitable and we never need lecture beggars about their loss of self-respect. When the getting of something for nothing becomes impossible, and never till then, will men cease to endeavor to get something for nothing. When you and every one of you completely discontinue giving alms except to those whose circumstances are perfectly understood, self-respect and other moral qualties will develop in those people without even a word being said to them upon that point. In giving to them *you* degrade society far more than they degrade it by asking. This kind of altruism is a curse in the world. Fawcett said of it:—"England was brought nearer the brink of ruin by the old poor law than she ever was by a hostile army." Meanwhile we should be self-respecting enough to admit that tramps and beggars are not very different from many "respectable" people after all.

INVESTIGATIONS IN GREAT BRITAIN.

Those who are interested to examine the economic results of giving to the poor, in England, Scotland and Ireland, will find plenty of books on the subject. The Encyclopædia Britannica contains a good article under the heading "poor law." See also other encyclopædias.

The Scotch are proverbially thrifty and economical and yet they have been degraded by the poor law of 1845. In some parts of Scotland there is ten times the poverty there is in Ireland. That law gives more relief than England's and the money is regarded as a nice gift. Those who had savings in banks transferred them to others. Careful investigation and even the labor test did not quell the applications in any such manner as did the Irish workhouse. Matters came to such a pass that the fishermen of Wick could not get their nets mended, their former assistants saying they could get a living easier from the parish.

In Ireland there is very little out-door relief, the proportion of Scotland being almost reversed — five in-door to one out-door pauper. In spite of Ireland's unjust land system and high rents the

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whole number of her paupers does not amount to one-half those of London alone. The Irish will submit to every privation rather than let friends go to the workhouse, which is the legal mode of relief and is not a charity.

In London many people get relief who could do without it and consider it no disgrace. Industry, economy, temperance and self-restraint would enable most of them to take care of themselves if they would. Hence the work-house is a necessary restraint, being uncomfortable or even disgraceful. They therefore shun it. If they may eat without work in some other way, they will; if not, many of them will work. Why are these people in such condition? It is a duty we owe to society to ascertain what are their thoughts, what the motives that have led them to such lives. If the result is that the vices and injustices and prodigality of the rich have in part induced such results, let it be exposed boldly and fearlessly. If injustice in the wage system and in land tenure is the cause in part, let this also be proclaimed.

INVESTIGATIONS IN THE UNITED STATES.

You will, however, be more interested in some figures from our own experience. The Hon. Seth Low, ex-mayor of Brooklyn, N. Y., presented a paper in 1881 at the eighth national conference of charities and corrections in Boston which Robert Treat Paine calls the corner-stone of relief reform. In it Mr. Low sums up his opinion of the world's experience in giving alms (technically called out-door relief.) Of the supposed beneficiaries he says:—

1. That it saps their habits of industry.
2. That it discourages habits of frugality.
3. That it encourages improvident and wretched marriages.
4. That it produces discontent.

His own conclusion as to what he had himself seen was "that out-door relief in the United States as elsewhere tends inevitably and surely to increase pauperism." Here are some of his statistics:

In Brooklyn, during 1877, 46,350 people were relieved at a cost of $141,207. In 1878 no money was given. This immense number of people which had received aid were left to take care of themselves or to go to almshouse or to hospital. What effect on these institutions did refusing to give to 46,350 people have? In 1877 and 1878 these institutions contained 1,371 people; in 1879, 1,389 people; in 1880, 1,199, and in 1881 only 1,171. What became of

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the people that had received the $141,207, in a single year? Mr. Seth Low says: "Instead of Brooklyn needing as the result of the abolition of out-door relief an almshouse of mammoth proportions, we find at the end of three years an almost imperceptible increase of sick paupers, but a steady diminution of well paupers; and this, too, in the face of a population in the county growing at the rate of 18,000 per annum." At about the same time similar action was taken in Philadelphia with like results. Cleveland's out-door relief account for six years was as follows:—

1875	to	4,590	families	$95,000.
1876	"	3,094	"	$85,000.
1877	"	2,386	"	$70,000.
1878	"	1,568	"	$32,300.
1879	"	1,550	"	$22,600.
1880	"	1,200	"	$17,000.

In March, 1877, was begun a system of requiring an equivalent for the relief furnished. Work at $1.00 per day was provided every man who being able-bodied applied for assistance. The officials were thoroughly convinced that pauperism had been fostered and increased by the old system.

Cincinnati pursued the same course with good results, except that it issued during ten winter weeks coal by the bushel; but even that was improvident and demoralizing. People who know a city issued coal last winter will count on getting it this winter and will take no other thought on the subject.

Now we know, by experiment, that the wise thing to do is to visit all such people in July and August and induce them to lay by a few cents a week for winter's coal, promising it to them at lower prices. If thus reminded to provide for winter they are less sensible than the squirrel; they must in all fairness to themselves be allowed to suffer discomfiture in winter and be taught by bitter experience. He who gives to the poor under such circumstances may be very benevolent at heart, but his influence is worse than that of a miser who refrains from giving.

A PERMISSIBLE FORM OF ALTRUISM.

What then must we do? Fortunately, our altruistic feelings may be gratified in a manner not harmful to the beneficiaries. Robert Treat Paine of Boston, who has had large experience in

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treating the poor, prescribes the following: "Whenever any family has fallen so low as to need relief, send to them at least one friend,— a patient, true, sympathizing, firm friend, to do for them all that a friend can do to discover and remove the causes of their dependence, and to help them up into independent self-support and self-respect." To which it may be added, if that friendly visitor is permitted to give alms, his and their minds are diverted from the great object,— the permanent cure of poverty. It should always be regretted when circumstances seem to demand attention to immediate needs. Put off every possible want till the person can himself supply it in a manly and independent way. Better a morsel with self-respect than plenty with an enfeebled determination to fight the battle of life.

II. ORPHAN ASYLUMS.

Much that has been said of giving alms applies to the treatment of delinquent and dependent children. Moved by the altruistic spirit, and feeling an approving conscience as the result of trying to do good to others, the Christian world has taken up the care of orphan asylums. Children are gathered from the slums of cities and sometimes from pretty good homes into these herding places. Then they are told, as I recently heard from a reverend doctor, how grateful they should be to Christianity for thus caring for them; but the fact again is that, prompted by kind motives, people thus try to do these children good without looking to the results of their acts to see the consequences.

EVILS OF ORPHAN ASYLUMS.

What then are some of these consequences?

1. That moral corruption brought in a little by each child leavens the whole lump.

2. That they are often placed under incompetent teachers to learn book lessons, when in fact their capacities call for manual training instead. (Who ever knew a scholar reared in an orphan asylum?)

3. They are fed in the cheapest sort of a way and clothed in a uniform that causes them to be pointed out always in public as objects of charity and degradation.

4. They are kept in herds and not in families and hence subject to rules and training necessitated by this abnormal life. Often

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they are so unfit to live in families that kind-hearted people not adopt them.

5. Every delinquent mother and every drunken father now kn that he and she can indulge their vices and get rid of their dren. Thousands of widowed mothers learning that they marry again if not encumbered with children are putting thei tle ones in asylums. The asylum thus offers a premium to desertion. Rich people even are living in luxury, while nephews, nieces and grandchildren are being corrupted in or asylums. The niece of a president of the United States was, long ago, in an asylum, while her uncle, aunt and three cou occupied the White House. Such people often give as their ex that the child was too vicious, or rude, or even homely, to b ceived into their families. "No one seemed to want him."

THE REMEDY.

Better the humble home of a poor farmer in the west, better for such children as are unavoidably orphaned, than t unnatural corrals. But this kind of orphans constitutes not one-fifth of all. The other four-fifths represent indulgence the asylum founders and managers, towards parents and relat who wish to shirk responsibilities imposed by nature upon th With every such indulgence issues moral miasma upon soc which festers and reproduces its kind. And all this time pe with good motives and benevolent spirits thank God they are as other men are and proceed to build additional asylums. B and far better live and die among the Zuñi Indians of New M ico, having never heard of Christian charity, than to die leave your orphan child alone in a large city of the United St In the latter case he goes to an asylum to be swallowed up in masses. In the former case, although he has lost his own fa and mother, he has found many fathers and many mothers a whom will feel a personal interest in him and responsibility for h and who will share with him if need be the last pot of corn, will weep over his grave as if it contained their own flesh and bl We should need no orphan asylums if we possessed the virtu the Zuñi.

How to set forth the economic effects of such institutions, to point out to society the way to make its members rear the dren to whom they have given birth, and to show the disastrou

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fects of ill-considered altruism is a task which comes within the province of this section of the A. A. A. S.

III. FOUNDLING ASYLUMS.

Here again sentimentalism has contributed money to build asylums, and even more unwisely than in the case of the orphans. An orphan cannot be committed without something being known of its parents, or their circumstances, and without formal papers of transfer. This routine exposes many frauds and leads managers to reject thousands of applicants for admission. Managers like to boast of the cases they have rejected. With foundlings nothing of the sort occurs. The girl whose yieldings to temptation have made her a mother, be she in high life or in low, the intemperate who prefer to use their means for drink to rearing their own offspring, the society people who have boasted that there will be no children in their families—one and all—have but to leave their offspring as naked as little Moses was when deposited at the Nile, either in a vacant lot or upon some handy doorstep. Under cover of darkness all is secret. Either a policeman, or the irate citizen whose doorstep has been invaded, quickly and safely transfers the waif to an asylum. The reminders of sin and folly as well as the burdens of the parents have thus been put far away. Were society organized to encourage this very business it were impossible to arrange it more satisfactorily. But eternal shame should rest upon the weak-minded, benevolent people who by their ill-advised altruism cultivate such degradation in society. One-tenth of the money spent in detecting and punishing these parents for their unnatural crimes would teach society the needed lesson. More pains than we take to catch a murderer should be spent upon detecting these criminals. Every foundling asylum in America should be instantly disorganized.

IV. INSANE ASYLUMS.

Upon this kind of altruistic effort, also a boast of the age, there are not sufficient data to warrant so severe denunciation. It is proper, however, to call attention to some suspicious circumstances.

1. The collecting and imprisoning of great masses of such people is unnatural and the best authorities advocate breaking up the system by substituting homes and separate buildings.

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2. To the non-medical observer it is surprising, that while rapid progress is being made in treating many forms of disease such as are caused by minute germs, so little knowledge is being obtained concerning the nature, causes and cure of insanity. With many physicians, supported by the state in a liberal manner, why are they not bringing forth fruit in this direction? It is said to be because incapable men get places through intrigues and because so much time is spent in routine work.

3. The number of the insane is on the increase. Some of the immediate causes are understood. Is it not certainly of the utmost importance that facts bearing on these points be circulated and that great effort be made to check insanity by rooting out of society the immediate and ultimate causes.

The altruistic work suggested by these questions can have no unjustifiable effects. That which has been performed is more questionable as implied by the changes proposed and upon further examination may prove more unjustifiable. In any event it is plain that doing good to those now insane may not be of half the importance that it is to find means of preventing insanity in the future.

V. BENEVOLENCE IN HIGHER EDUCATION.

It used to be a practice to give not only tuition but even board and clothes to young men studying theology. It was considered that they were preparing to lead lives devoted to altruistic work and that it was therefore desirable, in the case of young men apparently without means, to pay their expenses in theological schools, but it worked so badly that the plan is undergoing change. In the best schools where funds are provided, they are now loaned and a written obligation to repay is executed. In other words the managers of schools of divinity found out that to give to the poor theological student was to lend to the devil,— a very different creditor from the one they had in mind. It was found that this money got used at times for tobacco, for pleasure trips, etc., while board bills were unpaid, and that after it was spent the beneficiaries sometimes abandoned the life-work they had contemplated.[1] But even the loan system is not working satisfactorily. The written obli-

[1] There has been in government employ in Washington, the past eight years, a young man who received such aid for two years previously. He now owns real estate in Washington, but he never preaches.

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gation is often lightly esteemed and held to be not binding. The writer's latest information is that but thirty per cent. is paid back. Only when the notes are looked after, as a successful banker looks after his paper, will the system become truly beneficent. It will then have ceased to be a charity. Again let it be said, *do not give something for nothing*, but if you really must do so, then put it into a lottery.

VI. GIFTS TO WORKINGMEN.

There is reserved for the last a notice of the most contemptible form of altruism now known to civilization. It has come to be the fashion for people who have acquired money without giving an equivalent in labor and who wish to indulge in benevolence, to build mission chapels in outskirts of cities, and to furnish them with cheap appliances in order to "save the souls" of the dear working classes. Another form this takes is in furnishing workingmen libraries and reading-rooms, and even in building improved tenement houses. In a score of ways the rich are "doing something for the poor." Now all these things have the same surface appearance of charity as throwing a dime to a beggar. But the fact is that these people have by class legislation or dishonesty gotten possession of wealth created by the poor, and in order to quiet their little consciences, or occasionally in order to enable them to keep up the fraud, they dispense these charities.

Now let it be reported to all such that the workingmen need none of their charities. They cry out for justice, for fair wages for a day's work, for reasonable rents, for a chance to buy house lots which speculators have not pushed beyond honest men's reach, — in short for such a reorganization of legislation and custom as will enable them to labor and to administer upon the entire fruits of their labor, to build and furnish their own chapels if they choose, to establish their own libraries and reading-rooms, to build their own tenement houses and to scorn charity as they now have good reason to scorn such dispensers of charity.

CONCLUSION.

The basing of all so-called charitable and benevolent work upon such principles as have been indicated, or rather the substitution of right-seeking and right-doing (which is but the simple prac-

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tice of justice) will require earnest study and a great change in our spirit and methods. Those who in preceding years have here listened to outlines of work adapted for this section as presented by Professor Elliott and Major Alvord should notice that the bounds will be much enlarged if we seek to solve the problems which shall enable us to make our altruism economically beneficial. This certainly should be the case. That we should pretend to be doing good to all men and yet be deceiving both ourselves and them, while really doing harm to both, needs only to be demonstrated to secure our condemnation. And giving alms to show even to ourselves our good motives or in order to indulge our benevolent impulses is certainly the most deceitful form of selfishness, since it appears in the form of altruism, is evil and only evil.

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PAPERS READ.

THE USE AND ABUSE OF STATISTICS. By EDWARD ATKINSON, Boston, Mass.

[ABSTRACT.]

I CAN cite no more true example of the use of statistics than the admitted necessity on the part of every merchant and manufacturer to keep a set of Books of Account in which the statistics of his business are registered day by day. In the course of a business life now covering more than forty years I have known more failures in business growing out of the neglect of the use of statistics in this manner: *i. e.*, more failures arising from want of knowledge on the part of the merchant or manufacturer of the actual figures of his business than from any other single cause, and perhaps more from this cause than from all other causes of failure put together. Yet the merchant or manufacturer, who attempts to govern his affairs and to guide his business merely by the application of statistics without applying his own judgment in determining what the figures mean, is sure to fail—whether these statistics are recorded on his Books of Account or are the mere statistics of the trade in which he has been engaged.

Whenever a man is wholly guided in the purchase of materials by the statistics of the crop, say, of cotton, and pays no regard to other conditions he may make a profit for one, two or three years, but he is sure to come to grief sooner or later. This has been the common observation of all who have watched the figures of the cotton crop and the course of prices together for any long term of years. These are commonplace examples of the use and abuse of statistics.

I will limit the short treatise which I present to-day mainly to some examples of the abuse of statistics of a more general kind.

The most conspicuous example of this abuse is to be found in the customary reasoning which is based wholly upon compilations of the rates of wages which are said to be paid in this and in other countries. The greater the truth of these comparisons the greater may be the falsehood in the deductions which are made from them. The rates of wages in all the principal branches of manufacture, in the mechanic arts and in agriculture, are unquestionably very much higher in this country than in any other, with the possible exception of Australia and New Zealand; they are decidedly higher than in Great Britain, but the rates of wages in Great Britain are also higher than they are in Ireland, two parts of the same kingdom, governed under substantially the same laws, taxed under substantially the same system, and subject to absolutely the same system of duties on foreign imports.

It is curious to observe that when the union of Ireland was pending, the manufacturers of Lancashire and Yorkshire presented urgent petitions

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against such union, upon the ground that if the two parts of the kingdom were brought under the same tariff the manufacturers of England would be ruined by the cheap labor of Ireland and would be obliged to let the capital invested in Lancashire and Yorkshire go to waste and to construct new mills in Ireland in order to avail themselves of low-priced labor which they then conceived to be cheap labor. There can be no greater fallacy than the conception that low-priced labor is the same as cheap labor; *i. e.*, labor that can be made use of at low cost.

Again, in passing from Great Britain to the Continent,—the rates of wages are lower in France than in England; in Belgium than in France; in Germany than in Belgium; in Italy than in Germany; in Austria than in Italy; in Russia than in Austria; and if we pass on to Asia, lower in China and India than in Russia. What more profound abuse of statistics could there be than in deducing the relative cost of production by a comparison of the rates of wages, which thus vary even in different parts of the same kingdom as well as in different countries.

Again, the rates of wages in the several states of this country vary greatly, although not as much as they do in Europe; yet if one were to attempt to get at the cost of any branch of work by the rate of wages, he would find that the lowest cost of production of any given article would not be found where the rates of wages were lowest, but rather where the rates of wages were highest. This leads to the consideration of the source of wages.

The old conception of wages being derived from a fund of capital previously accumulated has been substantially given up and the wage-fund theory, which even as late as the earlier writings of Mill had been fully accepted by economists, has been proved to be without any substantial foundation in fact.

In place of this false theory which has worked a vast deal of mischief, it is now generally conceded that wages are derived from the product on which the work has been exerted. Hence it follows of necessity that where the conditions are most favorable, *i. e.*, climate, soil, relative humidity, proximity to the material of chief value; or where there is a population bred to the necessary conditions of the work possessing an inherited aptitude for the specific occupation; or where the burden of local taxation is least,— *there* certain kinds of industry will become established under the best and most favorable conditions.

This product being brought into the market is sold at the same price as that which is produced under less favorable conditions; hence when the return is made which is to be distributed in money, as profits and wages, the less number of persons who have been required to do the work under the most favorable conditions receive a larger share, *i. e.*, a larger rate of wages or earnings than those who have been occupied in the same art under the least favorable conditions. Hence it follows that aptitude, skill, capacity, good public credit, favorable conditions, good soil, good climate and the like, yet more a suitable education, tend to the production of all goods and wares at the lowest cost measured in terms of labor and also at the highest rates of wages measured in terms of money.

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If then, it is true that the people of the United States possess the widest area of fertile soil, the greatest variety of favorable conditions in respect to climate, the largest supply of ores, coal and timber, the best schools, the lightest taxation, the greatest freedom in interstate commerce and service,—it must of necessity follow that with the exception of a few tropical products or a few branches of industry, like the preparation of tea which is absolutely a handicraft, or the preparation of raw silk which in the reeling is also absolutely a handicraft,—the people of the United States will produce the largest product at the lowest cost and will therefore secure the highest rates of wages or earnings; such is proved to be the fact by statistics which cannot be gainsaid.

The working of these laws may be to some extent retarded or obstructed by legislation; one of the worst cases of injurious or obstructive legislation is the substitution of *fiat* money such as Government notes or other forms of inconvertible paper, in place of true coined money made of metal which carries its own value in its own substance. There can be no better examples of the possible abuse of statistics than an exhibit of the relative conditions of prices, wages and volume of money in circulation for the last twenty-five years, which taken separately wholly mislead the compiler.

I have taken from the Census Volume No. xx the statistics of wages of all the mechanics, engineers, carpenters, machinists and painters which are given separately in all the returns of specific establishments contained in that volume. They constitute a class whose earnings or wages at any given time are more nearly even and more near to the average of all wages than that of any other single class of operatives or working people. They have been much misled by special statistics. For instance, in 1860, reference being made to the Table which accompanies this treatise, their average daily wages came to $1.56; in 1865 their average daily earnings came to $2.34. Their minds were abused by these statistics and they thought they were better off; but when we take the price of food, fuel and materials for clothing corresponding to the average consumption of this class of men and their families, the same quantities of the same kinds which could be bought at 30.95 cents per day in 1860 had risen to 55.69 cents in 1865, so that a mechanic misled by his high wages could yet buy with his 300 days' work only 1261 portions of this food, fuel and materials for clothing against 1572 portions in 1860; after 1870 wages began to decline, but prices went down faster; after the resumption of specie payment in 1880 the rate of wages advanced, but the quality of the money being good, prices still continued to decline; and in 1885 and 1886 this same set of mechanics earned $2.40 a day in gold with which they could buy 2400 portions, or very nearly double what they could get at substantially the same rate of wages in 1865, then paid in depreciated paper.

Unless all the qualifying conditions are taken into view, almost all statistics of wages are absolutely worse than useless.

Again, much importance is attributed to the quantity of money in circulation. A few words may be devoted to this subject.

According to a compilation recently made by the Secretary of the Treasury, the quantity of all kinds of money which was in circulation in 1860 was

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$14.06 per capita; in 1865, after the issue of the *fiat* money, the c
was $33.96 per head; yet, as I have proved to you, the condition
workman was much worse at this time than it had been in 1860 w
quantity of money in circulation was only $14.06 per head. Fro
down to the resumption of specie payment in 1879, the quantity of
per capita steadily diminished through the withdrawal or contra
the paper money. In 1880, after the resumption the quantity of a
of money in circulation redeemable in coin, or in coin itself, was $2
head, nominally nearly $10 less per capita than in 1865; yet every o
pered, business was active, the rate of interest was low, the rates o
were nearly as high as they had been in 1865, while the purchasing
of the money had greatly increased, as the diagram will show.

Since 1880, there has been a steady expansion of the quantity of
in circulation. The instruments of exchange now consist of gold
certificates based thereon; silver coin or certificates; legal tender no
bank notes, all practically redeemable on a gold basis; the amount
or available for use, is now $27.25 per capita; yet prices are not as
they were in 1880, while wages are higher and the purchasing po
wages is greater than ever before.

There are now, however, certain forces in action which tend to di
the amount of money per capita. The excess of revenue tends to
cumulation of money in the Treasury of the United States and th
fear lest there should be an undue contraction of the currency. Th
may perhaps be dispelled by a consideration of the actual facts.

The excess of revenue falls into the Treasury either in legal-tende
which, when in the Treasury, become evidence of so much debt paid;
the revenue comes in coin with which these notes may be red
This accumulation may go on to the extent of the probable excess
enue for one year to come, to wit, $125,000,000. It may all consist o
tender notes; this accumulation will reduce the currency per capit
per head. Does it not of necessity follow that there will not be e
Deduct $2.00 per head from the amount now in use or in circulat
wit, $27.25, and the remainder $25.25 will exceed the whole volume
rency of 1880 which was sufficient to do all the work that was requ
it. It might not therefore be any misfortune if Congress should fai
duce the revenue and if this accumulation should go on until every
tender note should either be liquidated by taxation or be sustained b
dollar for dollar, in the Treasury of the United States.

To this end all the statistics now point.

I have thus brought before you in a very concise way the relation of
wages, purchasing power of wages, and volume of money per capit
tervals of five years from 1860 to the present time. You are all wit
to the abuse of statistics in the separate comparisons of rates of
and prices of goods, on which separate comparisons many adverse c
sions as to the condition of the country have been based. Does
true use of these statistics wholly consist in grouping them togeth
certaining their relation each to the other and then deducing from
facts such conclusions as they may indicate? In other words, may

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be held that unless statistics are made use of as a basis of economic reasoning by persons competently trained, they become a mere snare and pitfall, working more harm than good through the false deductions that may be made from them, while, on the other hand, the economist who attempts to reason on the conditions of men in their relation to each other, without regard to the statistics of prices, wages, volume of currency and other elements by which the exchange of services is controlled or measured, will of necessity be a mere theorist whose unsustained hypotheses may or may not come near the mark?

RELATION OF WAGES—PRICES—PURCHASING POWER OF WAGES AND VOLUME PER CAPITA OF MONEY OR CURRENCY IN CIRCULATION AT THE RESPECTIVE DATES GIVEN.

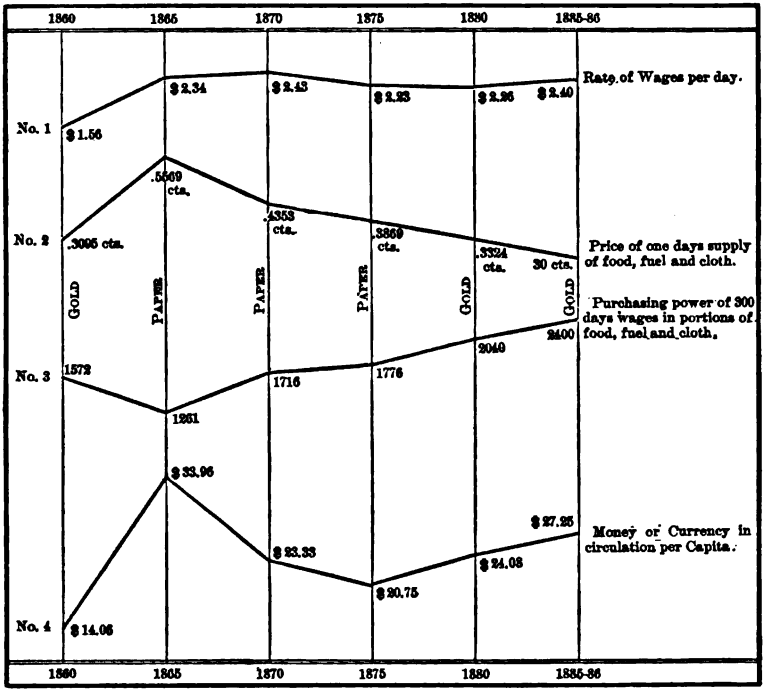

DIAGRAM NO. 1.

No. 1. Average wages of mechanics, such as engineers, carpenters, machinists, and painters, connected with the mills and works treated in Vol. XX, United States Census—establishments in eastern, middle and western states.

No. 2. Average cost of one day's supply of food, fuel and materials for clothing, customarily used by such mechanics, computed at retail prices in twenty shops—ten east and ten west of Buffalo, N. Y.

No. 3. Variation in the purchasing power of 300 days' wages in money expended for equal portions of the same kinds of food, fuel and cloth, as above given.

No. 4. Quantity per capita of coin, convertible bank notes, legal tender notes, in circulation or in use as money at the respective dates.

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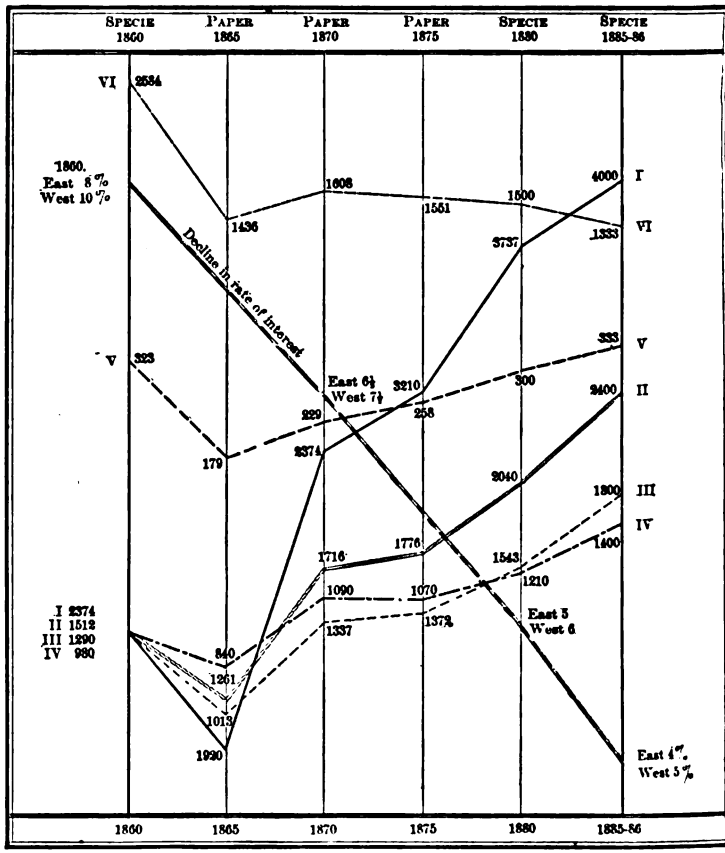

DIAGRAM NO. 2.

The foregoing table has been computed by taking the prices of equal quantities of the same kinds of food, fuel and materials for clothing at different dates, corresponding in kind and quantity to the average consumption of good mechanics in the eastern and middle states. The upper line numbered VI, represents the loss in the purchasing power of the income of ten thousand dollars invested in safe securities. The result is reached by dividing the price of a single portion or day's supply of food, fuel and materials for clothing at the different periods named, into the sum of the interest which could be earned at the different dates on ten thousand dollars invested in the safest manner.

The next line crossing the table diagonally from left to right gives the average decline in the rate of interest on the best commercial paper between the dates named.

The third line numbered V, represents the purchasing power of one hundred dollars of lawful money converted into portions representing a quantity equal to one day's supply of food, fuel and materials for clothing at the respective dates named.

The four lines, starting from the same point numbered in Roman numerals, I, II, III, and IV, represent the purchasing power of three hundred days' wages at the average rates earned, when converted into similar portions or days' supply of food, fuel and material for clothing.

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I. Specially skilled mechanics, overseers, foremen and the like.

II. Journeymen, mechanics of average skill and capacity.

III. Operatives in factories of various kinds, textile, wood-working, boots and shoes, metal works and the like.

IV. Common laborers.

The data from which these rates of wages and their purchasing power have been compiled are taken from one hundred establishments reported in volume twenty of the United States Census, compiled by Joseph D. Weeks. In selecting the establishments the writer chose among a very much greater number, one hundred which he had reason to suppose had been in substantially continuous occupation throughout the period from 1860 to 1885-6; or if subject to temporary stoppage, yet for very short periods.

In making these compilations the attempt has been made to devise a multiple standard at the prices prevailing of the actual necessities of life as a substitute for the unit or standard of money, which has varied so greatly between 1860 and 1885-6 in consequence of the issue of inconvertible paper money.

These tables are given as examples of what the writer considers the true use of statistics, in which the variation in prices, in the rates of wages and in the purchasing power of money are compiled and compared.

The common abuse of statistics consists in treating prices and rates of wages without any consideration of the quality or purchasing power of the money in which these prices and rates of wages are given. The depreciation of the legal tender notes of the United States from 1861 to 1879 have utterly vitiated all the statistics of that period relating to prices and wages unless the figures are adjusted to the variations in the value of the currency.

NEED OF A FOREST ADMINISTRATION FOR THE UNITED STATES. By B. E. FERNOW, Chief of Forestry Division, U. S. Department of Agriculture, Washington, D. C.

POLITICAL economy, as the name implies, is that science which teaches us, as a nation, to manage our resources, to avoid waste—waste of energy, waste of resources. In the United States it will be readily admitted this science of avoiding waste has not been much practised; our natural resources, especially, abundant as they were, have been and still are squandered in a manner which must needs frighten him, who has a thought for those that come after us.

Among the most useful resources to a nation of pioneers must have been the supply of material which the forest furnishes, and yet these very supplies so essential to the pioneer civilizer have been not only squandered most ruthlessly and unnecessarily, but the possibility for their natural recuperation — by which the forest excels all other natural resources — has, to a large extent, been wantonly destroyed or deteriorated.

That the farmer who needs the ground for agricultural use should have cleared away the timber growth immoderately, and often imprudently; that the lumberman and private forest owner should have prized the present realization of his forest value more than its higher prospective value, and should have cut and slashed without thought of economy, and, to overcome competition, expensive transportation, etc., should have wasted rather more than necessary, we can perhaps understand, explain and excuse.

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But that the government, without any need of a present income, should have so utterly neglected this branch of political economy and failed to perceive its interest and duty in the preservation and continuity of this richest of our resources, seems remarkable.

Our government has failed to recognize the importance of this factor of national wealth in general; and, worse, after having disposed of the largest part of it unconditionally, it has failed to take care of that part which was left in its own hands, as a trust for the people.

To make good the assertion that the forest supplies have been among the most important factors of our nation's wealth, I cite, from the calculations of Professor James, the comparison between the products of the forest and those of other industries as appearing upon the basis of the census of 1880.

"The value of the forest products in that year (1879) was equal to one-third of that of all farm products whatsoever sold, consumed or on hand. It exceeded by nearly one hundred million dollars the total assessed value of all the farming property in the New England States and by a somewhat smaller figure that of the farms of Virginia, North and South Carolina, Georgia, Alabama and Mississippi. It would have purchased at its assessed valuation for the purpose of taxation the entire property, personal and real, of all the citizens of the States: Vermont, Delaware, Florida, Arkansas, Nebraska, Colorado, Nevada, Oregon and of all the Territories besides and still have left a balance nearly equal to the same kind of property rated in the District of Columbia.

"If to the value of the total output of all our veins of gold, silver, coal, iron, copper, lead and zinc, were added the value of the product of stone quarries and petroleum wells and this sum were increased by the estimated value of all the steamboats, sailing vessels, canal boats, flat boats and barges plying in American waters and belonging to citizens of the United States, it would still be less than the value of the forest crop by a sum sufficient to purchase at cost of construction all the canals, buy up at par all the stock of the telegraph companies, pay their bonded debts and construct and equip all the telephone lines in the United States.

"This sum of 700,000,000 dollars exceeds the gross income of all the railroad and transportation companies in the United States and if we leave out New York and Pennsylvania, it would suffice to pay the public indebtedness of all other states in the Union, including that of all the counties, townships, school districts and cities within those States."

In a word, we have to do here with an interest, ranking third in the line of importance even from the mere view of dollars and cents, counting manufactures of all kinds first and agriculture second.

Now, while for education and for transportation, for agriculture and for manufacturing, the government has actively engaged in measures of promotion and has passed laws, looking to the preservation and increase of various forms of our natural wealth; while in the protection of game and fish, legislation has been active in almost every state; while by the establishment of a United States Fish Commission even the restocking of waters has been thought necessary; while millions of money have been expended for

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clearing out the channels of streams and regulating their flow and protecting adjacent property against their floods, nothing has been done to protect the head-waters, where such damage originates; nothing has been done to protect the natural regulators of waterflow; nothing has been done to keep the mountain forests in continuous reproduction; nothing has been done to foster the recuperation of this important source of wealth.

The laying of a protective tariff has, if anything, hastened the depletion and encouraged the wasteful use of our forest supplies and beyond that no action worth naming and adequate to the importance of the subject has been attempted by the Federal government.

While this must be considered poor political economy, the absence of appreciation of what is the duty of government in this direction is still more marked in the case of the disposition and administration of that part of the public domain, which bears or bore a timbergrowth.

That this part of the public domain had any special value, needed any special protection like other valuable property, required any special administration to preserve its material substance and to secure the continued existence of the special climatic and hydrologic functions which the forest serves, such views of our forest property have hardly entered the minds of our representatives, if we judge by their legislative acts.

Even the latest bill which attempts a reform in the disposal of public lands, just passed by the House of Representatives, while it recognizes the greater material value of timbered property, fails entirely to comprehend its national and cultural value, and the discussions on this bill reveal strikingly this lack of comprehension.

Although we find, since the act of March 2, 1831, several feeble attempts to prevent the theft of timber from the public domain, these attempts were so feeble and inadequate, as to render them not only ridiculous, but like all laws which cannot be enforced for lack of executive organization, mischievous and dangerous to the morals of the community.

Passing over the history of this property in the past, we find that it has rapidly dwindled down, until to-day the United States Government owns but fifty to seventy million acres of forest area, roughly estimated—we have no means of approximating it more definitely.

This property is largely situated on the mountain ranges of the Pacific Coast and the Rocky Mountains.

It is constantly being diminished in extent by the land syndicates, who obtain possession of it by circumventing the law, with bribery and perjury, since no legitimate manner of obtaining the timber exists.

For lack of proper regulations and in the absence of proper administration, the rest is being robbed of its best timber partly with, partly without sanction of law, but in both cases in the most wasteful manner.

During the last seven years the value of timber reported as stolen amounted to $36,719,852; what portion this may be of the actual amount stolen may be inferred from the statement that over an area covering geographically not less than one million square miles twenty-seven agents only in the average were employed to ferret out and bring to justice the depre-

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dators. The amounts actually recovered during this period, usua
compromise, amounted to $478,073, while the expense for this protect
service had cost $455,000.

So, after all, one of the commissioners of the Land Office could con
late himself that it was a "paying" service.

With more and more urgency have the commissioners of the Land
the officers to whose care, under the Secretary of the Interior, this pro
is intrusted, insisted that under existing laws and conditions and wit
deficient funds appropriated for the purpose not only is it impossible t
tect the property of the people against theft and devastation, but the
of the settler and the requirements of industrial pursuits being disre
ed by the law, the users of timber are by necessity forced to become
redators if they wish to satisfy their needs.

In addition to the spoliations of its direct material value, the publi
ber domain has suffered untold damage by reckless, willful or carele
ing and in every respect the management of this part of our nation
heritance reflects discredit on our much-praised business capacity.

That this is not the fault of the Executive, but of the Legislative b
of our government which withholds the necessary funds for a prop
ministration of this trust, will appear from the constantly reiterate
ommendations of the Secretary of the Interior, a few of which I c
exhibiting the legal and moral aspect of existing conditions.

The Secretary of the Interior, in 1880, after devoting over six pa
the subject of forestry, says:

"I regret to say that in spite of the repeated recommendation o
passage of a law to facilitate the prevention of the wasteful devastat
the public timber lands, and to enable the government to dispose o
ber to settlers and miners, as well as for legitimate mercantile pur
under such regulations as would prevent the indiscriminate and perm
destruction of our forests, almost all the legislation that has been had
this subject consisted in acts relieving those who had committed th
redations in the past of their responsibility and protecting them a
the legal consequences of their trespasses, etc."

And, in 1885, Secretary Lamar, repeating his recommendations in
and 1887:

"The subject of the preservation of timber on the government lan
been suggested to Congress repeatedly in the reports of my predece
Perhaps its frequent repetition has rendered it commonplace, until
come to be recognized as a part of routine report. Its importance
fies its repetition. That the timber is rapidly disappearing is an
putable fact. Much is wasted and destroyed. Its effect on rainfa
flow of our rivers, and the healthful character of climate are subject
thy of consideration. Its importance and necessity for agricultur
mestic, and mechanical uses require no portrayal. Good govern
while not forgetful of the present, should use some care for the f
Both on account of its present importance and its future necessit
subject is worthy of your thought."

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And further, speaking of the timber act of 1878:

"Its enactment was suggested, doubtless, by the fact that settlers in a new country, surrounded by woodland, could not and would not suffer in a rigorous climate for want of fuel and shelter; that the necessary industries of a frontier would not submit to the pinchings of a famine in the midst of abundance. But while it was necessary to recognize the inevitable, the recognition was not properly guarded, and waste and greedy speculation seem to have resulted from the law.

"Any timber for the uses named in the statute may be cut, under its provisions, by any resident of the Territory on any mineral lands of the Government, in the Territory of his residence, without compensation. Individual avarice and corporate greed, thus invited, with hasty eagerness, vie in accepting the bounty, and unless checked by wholesome modifications of the law, will soon cause all the mineral lands to be stripped of their forests. Railroads pass through many of the Territories; along their routes wealthy companies have been organized, mills erected, and the most valuable timber accessible is being rapidly cut off. That which is "every one's property is no one's care," and waste and extravagance are the natural consequence of negligent legislation."

The last report of the Commissioner of the Land Office (1887) contains a chapter illustrative of the manner in which a small minority has been for a long time defrauding the nation unchecked. Any citizen who feels himself a part of the great government "of the people, for the people, by the people" will do well to ponder over these pages of disgrace.

Under existing conditions not only is it made difficult for the resident population to supply itself with the needed lumber in an honest way, but the danger of doing so in contravention of the law entails an enormous, needless waste. Acres of timber are felled in anticipation of possible use, and rot on the ground, because their haulage may become too risky, or the depredator finds it difficult to dispose of the property, and so it is left to furnish food to the ever-recurring annual fires, which destroy not acres but miles of standing timber, and no legal disposition of the burnt timber may be made.

Such is the moral aspect of our present conditions in regard to the land laws and to the reasons for a change in our forest policy. The organic reasons are those which compel us to consider the forest cover of the mountains as of more importance than merely to supply material for the present.

That those who may cut timber legally on mineral lands, or homesteads, or timber entries on the Pacific slope, have no interest except to satisfy a present momentary need, and clear the land regardless of any consequences to future supply, or proper management, or forest conditions, utilizing only whatever part of the trees they may readily use or require, leaving the balance in the most wasteful manner on the ground, is attested by those acquainted with the manner of timber-cutting in those regions. Any sign of intelligent and systematic management which would insure a full utilization and continuity of the same is, of course, absent and not encouraged

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by present regulations under the existing laws, and local supplies are waning in many parts. While in view of the needs of local supply for mining operations, especially in mines yielding low-grade ores, which cannot bear the burden of heavy charges for the importation of their timbering, this is an undesirable prospect, a much more serious danger is threatening the community at large in and around these mountain regions.

The climate is, in many parts of the region, not favorable to tree growth; at least not to the germination of seeds of coniferous trees, which form there the natural growth. These unfavorable conditions are, by the act of man made still more unfavorable. The wholesale clearing which is practised lays bare the thin soil to the influence of drying sun and wind; fires that sweep over the ground without hindrance destroy the thin mold and whatever seedlings may have been on it, and thus natural recuperation of the forest is made impossible, and any attempt at artificial reforesting is almost precluded. Barrenness and desolation are, as a rule, the result.

If, in view of so much graver consequences, it were permissible to allude to it, I would impress upon those who take a delight and a pride in the charm with which nature has endowed our country, vying with the finest scenery of Europe, that the beauty of the once verdant mountain sides is being ruthlessly and needlessly destroyed, and with such general equanimity is this devastation considered that we may soon substitute in our dictionaries the word "Americanism" for "vandalism."

What the graver consequences are can be readily understood by those who have studied the history of deforestation and forest devastation in southern France, Switzerland, Spain, Italy, and those far eastern countries which compare somewhat in climatic aspects with the region in question.

Not only is the forest cover of the mountain crests destroyed when it might have yielded continuous supplies, but at the same time agriculture in the valleys below is first endangered and then made impossible.

In a region which, like most of the plains of Idaho, Montana, Wyoming, Colorado, Utah, New Mexico, Arizona, and southern California, requires for agricultural purposes the aid of irrigation, regularity of water-supplies is all-important. This is being tampered with when the ground is laid bare on the mountain sides, allowing the rains to run off as from a roof and permitting the snows to melt and their waters to pour down in torrents at a time when more than enough water is on hand and the husbanding of the supplies for a later season is highly desirable.

Whatever may be the influence of the forest upon climatic conditions, its function as a regulator of hydrologic conditions is well understood and proved both by experience and experiment.

Other consequences, such as an increase of snow-slides and land-slides and the washing of débris into the valleys have begun to make themselves felt and it can only be a question of time when we must reach such a state of things as was brought upon the mountain districts of France, Switzerland, and the Tyrol, and which is too well known to be rehearsed again. I will only mention that after entire communities had been impoverished by the action of torrents due to deforestation the governments found it neces-

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sary to interfere, or rather, interference coming too late, to assume or aid in the work of reforestation. Thus in France it was found that 783,000 acres needed to be restocked for reasons of public utility, besides the securing of 1,900 miles of torrents. One hundred and three thousand one hundred and thirty-eight acres of mountain land are reported already as put in condition by the Government at a cost of $4,365,750, outside of the cost of expropriations, etc. To this must be added $1,116,643, which have been given to communities and private owners in aid of similar works, and a further expenditure of about $34,000,000 is expected to be necessary. Altogether it is estimated that $30,000,000 have been expended to correct the evils brought on by foolish disregard of nature's laws. For the year 1887, the appropriation for these purposes amounted to $794,000, the total appropriation for the forest department of France being in round numbers $5,000,000.

There has been lately a proposition brought forward to build reservoirs in the mountains for the purpose of water regulation. This same proposition was made in France, but it was soon abandoned as impracticable, costly and as liable to create new dangers, perhaps greater than the old ones, since the mountain reservoir might burst at any time and the embanked river was certain to rise above the surrounding plain to a dangerous level. The wiser plan of reforestation, therefore, was resorted to with results which now have proved the wisdom of that measure.

The public land commission in 1883, recommending necessary changes in existing land laws, says: "The timber lands should be sold. Will not private ownership, self-interest, best protect this class of lands?"

If the history of the countries just cited, if the forest lands in the older settled parts of our own country, have not shown that this is a fallacy, we may never expect to learn from experience.

While the existing system of espionage and police may be "unpopular and un-American," as it undoubtedly is, it exists, not because there is no other choice than sale, but because there are no adequate provisions made to satisfy the requirements of lumber for actual and commercial use, thus forcing the population to depredations. Settlers and consumers of wood cannot be expected to go to the woods and cut their sticks when wanted, as in the pioneer days. They must have an opportunity to supply their wants in a business manner, as they do in all other needs of civilized life; through the agency of a middle-man — in this case the lumberman or the saw-mill man — nor, with the absence of stability in our population, can more than a temporary or an ephemeral interest attach to forest property for the individual.

It is not the forest that is valuable and would appear worth its protection to the individual, but the timber which the forest yields. As soon as that is gone, the value and interest are gone for the individual. The interest which the community has in the forest is transcendent. The continuation, reproduction, and protection of the forest cover are of significance to the continued welfare of the community, especially in the mountain forests, and the mountain forests will therefore be in safer hands with the community at large, with the state.

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Let it not be overlooked that the state is not only the representati
communal interests as against individual interests, but also of futu
terests as against those of the present; that the forest is a kind of
of which the usufruct belongs to the present, and that to draw up
capital is a perversion of the trust and can only be excused by dires
cessity. Every other civilized country has found by severe experience
private interest is not sufficient to protect this class of lands; that
ownership or, what is more objectionable and less effective, state su
sion of private forest lands is indispensable in those regions where th
est subserves other functions than that of mere material supply.

We have then this proposition:

The United States owns a large forest property; owing to its locati
a comparatively sparsely timbered country, careful husbanding an
production is important for the development of the surrounding cou
owing to its location on the mountain sides and tops, within a com
tively arid region, which is dependent for its agricultural developme
irrigation, its continuity as forest is imperative for the regulation and e
ization of the waterflow in the mountain streams; experience and re
ing from the natural habits of private owners teach, that the expect
of indirect and distant benefits rarely induces such private manage
as is likely to curtail present profits, and that individual owners wi
be influenced in the management of their holdings by the interests an
resulting benefits to the community at large. Hence it is proposed th
United States Government reserve from disposal by sale or other e
the forest lands unfit for agricultural use which it owns, that it place
under a proper forest administration, which with due regard for the
of timber supply to the surrounding country will insure the continuit
recuperation of the forest cover.

I have embodied my views as to the precise organization of such a
ministration in a Bill, which has been before Congress during its las
sion, but in the turmoil of politics, in which political economy plays
small part, this measure could hardly expect serious consideration.
yet the time is not distant, when it may be too late to ask for such a
ministration, because there will be nothing to administer.

I now call the attention of the members of this section to the early a
of this same Association with reference to the subject of forestry.

At the Portland meeting in 1873 the Association appointed a Comm
upon Forestry, "to memorialize Congress and the several State le
tures upon the importance of promoting the cultivation of timber an
preservation of forests and to recommend proper legislation for sec
these objects;" Mr. G. B. Emerson being one of the Committee.

The result of this action and of the exertions of your Committee w
appropriation by Congress in 1876 to the Commissioner of Agricultu
the purpose of making inquiries relating to forestry, out of which
grown the present Division of Forestry in the Department of Agricul

Your Committee reported progress at the meetings in 1874, 1878
lastly, in 1880, it submitted a memorial designed for the various state
islatures, and asked for its discharge. With this the active influen

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the Association in shaping a forest policy for the country seems to have ended.

Several states have from their own initiative or as a result of individual and associated effort begun to give serious consideration to at least the management of their remaining state forest property, notably New York, California and Georgia. Not so the United States.

I, therefore, upon the grounds laid down in this paper, call upon this Association, through whose influence the only action for the promotion of forestry by the general government was secured, to further exert its influence in securing the more needful and more important action necessary to effect the reservation and administration of the remaining timber domain.

THE SCIENCE OF ECONOMIC ENGINEERING. By CHARLES S. HILL, Washington, D. C.

[ABSTRACT.]

EMBRACING the economic principles of developing, viz.:

1. Railroads.
2. Coast Defences.
3. Harbor Dependencies.
4. River Improvements.
5. Canals, Sluices of Irrigation, etc.
6. Public Education.
7. Shipbuilding.

Epitome: These economics constitute to the greatest degree, both civil and mechanical development of science, to constant employment of labor and to the grandest future of our nation in power, peace and prosperity.

These require wise economic legislation.

The development thereof is the only unification of capital and labor.

Arguments based upon the principles and precepts of Jefferson as a naturalist and political economist.

AN ERROR IN OUR NATIONAL DIETARY. By Prof. W. O. ATWATER, Middletown, Conn.

[ABSTRACT.]

EXAMINATIONS of the dietaries of a considerable number of people, in different parts of the country, show that their daily food contains an amount of nutritive material much in excess of the actual demand for nourishment. This excess consists largely of fatty substances and comes with the meats, which are consumed in great quantities. The meats in our markets contain much larger proportions of fat than is commonly supposed, a fact explained by our agricultural conditions and by physiological laws.

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SHIPBUILDING AND SHIPPING AS A NATIONAL ECONOMIC. By CHARLES S. HILL, Washington, D. C.

[ABSTRACT.]

THE prestige, decline and prospect.

Their importance in utilization of labor, in developing a Naval Reserve and in securing a home circulation of currency.

The want of economic national legislation to revive these industries or their irrevocable disappearance as American interests.

The national dependence consequent.

THE INTERNATIONAL STATISTICAL INSTITUTE. By J. R. DODGE, Washington, D. C.

[ABSTRACT.]

THE recent biennial session of this Institute in Rome, Italy.

Its work and propositions.

The pressing need of a system of international comparison.

The future purposes of the Institute.

ECONOMIC VALUE OF BINARY ARITHMETIC. By HENRY FARQUHAR, U. S. Coast Survey, Washington, D. C.

[ABSTRACT.]

THIS paper aims to show (1) why this arithmetic, in the notation used by Leibnitz, is unavailable in practice; (2) how that disadvantage can be avoided by an improved form of numerical symbols; (3) what evidence has been given by actual experiment of labor-saving by the use of the binary scale; (4) to what degree and why the binary scale may be considered the natural one.

SUGGESTIONS FOR LEGISLATION ON THE CURRENCY. By EDWARD H. AMMIDOWN, New York, N. Y.

IN all considerations of the use of silver money, a distinction must be plainly drawn between the intrinsic and the nominal (or legal) values of gold and silver coins. Their nominal values may, under favorable circumstances, be maintained at a uniform ratio by legislation. Their intrinsic

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values, depending upon the demand and supply of the precious metals, can never be permanent. And, as the conditions which determine the intrinsic values of gold and silver cannot be predicted, it is impossible to establish a ratio at which their intrinsic values can be maintained.

In the United States from 1790 to 1835, the intrinsic value of the silver dollar, as measured in gold, was less than its nominal value, and although the difference was only about five per cent, gold coins gradually disappeared. From 1835 to 1873, the position was reversed, and although the intrinsic value of the gold dollar, as measured in silver, was never more than five per cent below its nominal value, the silver dollar became a curiosity for collectors of rare coins. Since 1873, the intrinsic value of the silver dollar, as measured in gold, has again fallen below its nominal value, and gold coin, except as it appears in bank reserves or in the vaults of the treasury, is no longer an important part of the national currency.

In view of the great divergence which has taken place during the past ten years between the intrinsic value of silver, as measured by gold, and its nominal value in coin, it is commonly asserted that silver has declined in value; but it is also claimed by many that gold has increased in value; and with apparently good reasons, inasmuch as the world's annual product of gold has diminished during the past twenty years more than thirty per cent or from twenty-six millions to eighteen millions pounds sterling and its use in the arts and manufactures, together with its absorption in Asia, nearly equal at the present time its annual production.

Silver, on the contrary, has, as respects annual production, kept pace with the natural increase of the demand for it in the arts and for money, which has attended the growth of the world's civilization and trade. During the past ten years the product has increased about twenty per cent, or from seventeen millions to twenty-one millions pounds sterling per annum.

The effect of the diminishing production of gold upon its value has doubtless been largely augmented by the efforts of the European governments to substitute it for silver in the currency of their respective countries, thereby increasing the demand for gold concurrently with a rapidly decreasing supply.

The effect of these efforts upon the value of silver, lessening the demand concurrently with an increasing supply, must also have contributed not a little to the great change in the relative values of the two metals which is now disturbing the world's trade and everywhere provoking cries for relief.

How far the action of the United States, as a buyer of silver, during the past ten years to the extent of nearly one-third of the world's production, has neutralized European legislation adverse to silver, it is impossible to determine. But it is reasonable to believe that it has prevented a greater divergence of values between the precious metals and contributed in an important degree to maintain stability in the commercial relations of nations and individuals.

In view of the fluctuations of value in the past and of the certainty that

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they will continue in the future, it is evident that the concurrent use of both gold and silver money, at constant relative values, can only be maintained by arbitrary law, prescribing the ratio at which they shall be interchanged, and at which they shall be received in payment of debts.

In the absence of such law coins of inferior intrinsic value could not be kept in circulation. But if, under the operation of law, coins of inferior intrinsic value are unduly forced into circulation, all coins of superior intrinsic value will be gradually absorbed by bankers and dealers in money; or, if the balance of trade is unfavorable, will be exported. Foreigners estimate our coin mainly at its intrinsic value, and elect payment of debts in that kind which has the highest metallic value, as compared with its nominal value. No apprehension need however be felt in regard to the export of either of the precious metals, whatever be their relative values, so long as a balance of trade in our favor is maintained. During the six years, 1880 to 1886, with favorable trade balances, this country has steadily continued to draw gold from Europe, and to export silver, in spite of the superior intrinsic value of the former. The net amount of gold received during that time is about $120,000,000, while the net amount of silver exported is about $60,000,000. The Treasury reports show that silver has been exported chiefly to those countries which use it most extensively for coin and in the arts, while the imports of gold have been from those countries with which our trade balances are finally adjusted. Silver has been exported as a metal for conversion to the uses of foreign nations. Gold has been imported in settlement of debt to this nation.

But while bi-metalism is possible only by force of law, no law can maintain it in the presence of permanently adverse trade-balances, and it is a problem for statesmen to determine to what limit, even if supported by favorable trade-balances, the force of law will, under given conditions, ensure the concurrent use of both kinds of coin. It is also their duty, if bimetallism is desired, to guard against the transgression of that limit as well by encouraging the use of both, as by opposing all influences whether local or national tending to discredit either.

It is not essential nor desirable that the relative metallic values of gold and silver coins should be changed to correspond with the fluctuations of the market value of bullion, in order to secure their constant concurrent use as money. Variations in the production or use of either metal would speedily derange any ratio for the value of coins based upon the relative value of the metals. There are indications at the present time in the discovery of gold in South America and in the growing demand in Europe for more silver money, that the price of silver as measured by gold will be higher and that the nominal values of coins of the two metals will again approximate to their intrinsic values. The stability of our coinage will, therefore, be more surely maintained by avoiding any change in its composition.

The objections which are often made to the purchase of bullion for coinage, and the claim that coinage should be free, seem rather to be founded upon former usage than upon any valid reason. When, for long periods,

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the relative values of gold and silver continued nearly uniform, and the influences affecting their values operated slowly and insensibly, free coinage was neither unreasonable nor prejudicial. It was a natural consequence of the assumed right of governments to the exclusive control of the coinage.

But, at this day, when the fluctuations of values of the precious metals are great and the conditions affecting their values are promptly known, no nation can justly permit free coinage of either metal or allow individuals to profit by the difference, which may at any time prevail, between the higher legal value of coin and its lower metallic value. It is certain that individuals will not turn metal into a coin at a loss. Is there any good reason why the government should not reap the profit of coinage for the benefit of the people at whose expense the mint is sustained?

It is sometimes urged that the purchase of bullion for coinage involves an increase of taxation, but it is evident that this cannot be true unless it produces an excess of idle money in the treasury, and only to the extent of the loss of interest on this excess. A large fund must be constantly at hand to meet current expenses. If a larger sum than is required for this purpose is at times accumulated, any loss of interest upon it will be materially, if not wholly, offset by the profit accruing from the purchase of bullion.

It may be fairly claimed that such purchases would be generally confined to that metal which, for the time, might be of lower intrinsic value as compared with its nominal value. The advantage of this course in maintaining the equilibrium of value between the two metals, as well as in profit to the government, is obvious.

It is scarcely necessary at this day to contend for the maintenance of bi metalism in the United States. The American people with almost instinctive regard for their own welfare, have determined that question. But it is not irrelevant to point out that it is for the advantage of the whole world that silver be continued in general use as money, on a parity with gold, and by force of law, to the largest practicable extent.

It is admitted that the scarcity of money involves the depression of the value of all other property and universal distress. However much individual or national credits, in the form of checks, bank bills, or paper money, may take the place of coin in business transactions, silver and gold money are as essential as ever and in a constantly increasing degree, for the convenience of mankind, as a basis and measure of values, for which no substitute has ever been, or, have we reason to think, ever will be found.

The historian, Alison, traces the decline of the Roman empire (among other causes) to the diminishing product of the mines of Spain. On the other hand, he attributes the vigorous advance of modern civilization in the sixteenth century, in no small degree, to the vast addition to the world's stock of gold and silver in consequence of the discovery of America. There are not wanting men of the highest intelligence on this subject who distinctly trace the prosperity of the whole world during the fifth and sixth decades of this century to the gold and silver products of

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America and Australia. And eminent authorities now attribute the
prevailing among all nations without exception—(happily less in th
ed States than elsewhere, due to our control of the precious metals
world by means of our credit trade-balance)—to the gradual and c
diminution of the world's production of gold during the past twenty
Whatever credence may be given to these opinions — and it is b
that they have not been successfully controverted— it is certainly t
of wisdom and prudence to prevent the demonetization of either
precious metals and to afford every practicable facility for extend
use of both silver and gold money in proportion as the expandin
ness of the world may demand or justify it.

The power has been given in the Constitution and thereby the d
posed upon the Government of the United States, to coin money a
ulate the value thereof. President Jackson, in his message of
1836, says, "It was the purpose of the Convention to establish a c
consisting of the precious metals." Daniel Webster said in a speec
ed by George Bancroft in his recent "Plea for the Constitution
"There can be no legal tender in this country under the authority
Government but gold and silver."

Although, under the stress of civil war and justified by the supre
of self-preservation, paper was by authority of government mad
tender, it may be confidently asserted that at no distant day the em
will be considered the only ground for its justification. The dec
the supreme court which declares that "*it is consistent with the le
the spirit of the constitution*" will then be reversed, and the judgm
the great framers and early expounders of that instrument, as ex
by Webster, be irrevocably confirmed.

No consideration of the coinage of silver or of the extent to w
may form part of the money of the country will be complete whi
not contemplate the ultimate withdrawal of legal tender notes and
toration of gold and silver money to its rightful place as the only
tutional legal tender, and the basis for all substitutes for money,
certificates of deposit and bank notes, which have been invented
come necessary for the convenience of business.

The withdrawal of the legal tender notes would liberate the reser
of $100,000,000, now held by the treasury to protect the pledge
government to redeem the legal tender notes in coin on demand
loss incurred by the redemption of the notes would be the interest
amount of the notes in excess of the reserve held to protect th
may be estimated at three per cent on $250,000,000 or $7,500,000
num. For this comparatively insignificant sum the country wou
the advantage of an absolutely sound metallic legal-tender currency
retreat from a doubtful construction if not a dangerous violation of
stitution — the substitution in our currency of a large amount of
international value, for paper of no value—a broader and more sub
basis for the business of the country and therefore greater unifor
the supply of money and in the rate of interest, with a proportiona

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from convulsive depressions in the value of property and from disasters in business.

The more extensive use of gold and silver money, which would follow the withdrawal of the legal tender notes, would be still further promoted by any diminution of the issues of national bank notes. It seems to be conceded that under the existing requirement of a deposit of United States bonds to secure the holder of bank notes, the declining rate of interest on the bonds is gradually rendering bank circulation unprofitable except during brief periods of prevailing high rates of interest.

The tendency of the money markets of the world, with increasing facilities for transferring money from one country to another, indicates for the future more uniform and generally lower rates of interest in all important commercial centres.

It is therefore probable that to some extent the use of gold and silver will be extended by the withdrawal of bank circulation. But it is not desirable that this should take place to any important degree. Banks for local issues of currency have become thoroughly incorporated into our financial system, and perform the indispensable function of regulating the expansion and contraction of the currency in conformity with the requirements of trade. This important function could not possibly be so well performed in any other way, and certainly no one could wish to see it transferred to the control of the government.

The use and circulation of silver money might be considerably augmented by paying the United States bonds and the interest as it accrues thereon in silver as well as gold coin. It cannot be successfully maintained that the outstanding bonds and the interest thereon may not rightfully be paid in either gold or silver coin or certificates, and so long as silver coin is kept upon a par with gold coin interchangeable one with the other in the purchase of commodities and the payment of debts, the value of the bonds and the esteem in which they are held for investments, would not thereby be necessarily depreciated either at home or abroad. On the other hand, the concurrent use of both gold and silver coin in payment of the bonded debt and interest, at the convenience of the government, would tend to make the intrinsic value of the two metals correspond more nearly to their nominal values in coin and partially counteract the effect of the demonetization of silver in Europe. One of the consequences of European legislation adverse to silver money, with the collateral larger demand for gold, has been to augment our national debt and the interest payment, if they are required to be paid in gold, to whatever extent it may be found that gold has appreciated during the last twenty years. Some conception of the degree of the appreciation of gold may be formed by comparing its purchasing value in commodities in 1875 and in 1885, although not all the decline in prices which will be found can justly be ascribed to any one cause exclusively. No inconsiderable part of it is due to increased facilities for transportation and improved methods of manufacture. To continue to pay our bonded debt and the interest thereon in gold or not to pay a large proportion of them hereafter in silver will not only close a

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possible use for silver but strengthen the hands of those gover which have dishonored it, contribute to the support of gold mono-m and thereby augment the burden of our national debt.

It may be said that silver money paid out on account of the nation would be immediately returned through the custom house and l creased circulation be thereby obtained. But to this it may be repli silver money paid in this way will remain in circulation as long as out in any other way; and as long as any other kind of money wo main in circulation; the length of time will be determined not by th ity of the coin so long as parity is maintained, but by the pre requirements of business. All kinds of money including not only g silver, but their substitutes, national notes, bank bills, certificate gold and silver, in times of stagnation in business, are accumulate treasury and in public and private banks, lying idle and unproduct cause the diminished business of the country cannot use them pro

It is therefore no objection to the use of silver money or to which provides for coining it, that a large amount of it lies in the v the treasury, or that it is impossible to keep in circulation all that h coined.

The issue of certificates, limited by law to actual deposits of silv is one of the least objectionable and most effective means to prom use of silver money. It has the advantage of allowing the use sums without burden and the further advantage of saving the loss sion which follows the use of the coin itself. It also gives to the ment the benefit arising from the loss of certificates, which will in amount to a considerable sum, and probably sufficient to cover the storing the coin and issuing the certificates.

To what extent silver money may be issued, either in coin or by cates of deposit, consistently with the concurrent use of gold coin, c be determined by experience.

The existing conditions governing the solution of this proble never prevailed before, and they are changing from day to day. them may be considered the volume of the world's business, its a the facilities and methods of local and international intercourse, t trivances for the substitution of credits for money, the action of governments, the changing customs of trade in Asiatic countries, creasing demand for silver in those countries as their population an increase, and the growing home demand which would follow the ab ment of paper legal-tender, the reduction of bank issues, and the silver coin or certificates in payment of the national debt.

The policy of the nation on this question is therefore tentative, ing in its successful management an intelligent study of all the con which control it, and a broad and liberal view of our national in

The experience of other countries justifies the conclusion that larger amount of silver money may be used advantageously in the States than is now used. Not only France, which employs more tha as much silver money as this country, but Germany, which is preë

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ly hostile to silver, and other important nations furnish evidence that the amount of silver money in use here is far below the capacity of our people to employ with advantage. The rapid growth of our population also, of necessity, demands an increasing amount of money in circulation and especially that kind of money which passes from hand to hand in small sums. This is peculiarly the province of silver money. The facilities offered by modern substitutes for money, such as checks and bills of exchange, serve the needs of large business transactions, and of the great bulk in value of the exchanges of the country. But they are not available in the daily transactions of the wage earners and of those, numerically the greater part of the people, who keep no bank accounts.

The field for the use of silver money is capable of great enlargement as population increases, and a country like ours, covering a vast area and sparsely settled, requires a larger per capita amount of silver money in circulation than smaller and more thickly settled countries where the people have readier access to the conveniences of modern commercial life.

It would appear, therefore, that financial legislation in the United States should aim to increase the demand and the use for gold and silver money throughout the country and to expand its volume in proportion to the growth of population and business. It should also encourage the free issue of national bank currency under similar rules to those which now prevail to secure the holders, and facilitate the easy and rapid expansion and contraction of its volume in harmony with the fluctuating requirements of trade.

Such a policy, intelligently and persistently followed, would give to the country a broad, substantial basis of metallic legal tender for its business transactions, and through the national bank currency furnish the means to maintain easily that equilibrium between the demand and the supply of money which is essential to continuous national prosperity.

THE PARITY OF MONEYS AS REGARDED BY ADAM SMITH, RICARDO AND MILL. By S. DANA HORTON.

[ABSTRACT.]

THIS paper was prepared in May, 1888, as an open letter, answering a question of a member of the English Royal Commission on Gold and Silver.

This Commission consists of twelve members, men of great distinction and competence, including prominent members of either House of Parliament, and has been engaged for two years in an inquiry into the whole matter of gold and silver money, the evils of the present situation, whether affecting England or India, and the possible remedies for these evils. The principal proposition for permanent amendment of the present disturbed monetary situation of the world is that of a triple or quadruple alliance of the great monetary powers, to assure equality before the law to the two

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money-metals. This remedy was first projected in Europe and Am
1876, when the great breach of parity between silver and gold o
A treatise of that year "Silver and Gold" (R. Clarke & Co., Cincin
the author of this paper, established in his view the conclusion th
the interest of each nation to promote such a mintage union, an
was in the power of the United States to assist materially in bringi
its establishment. This policy was in the end adopted by Congre
coinage of silver was defeated by the Allison amendment of the
"Bland Bill" and the second section of the act of February 28, 1878
the nations to a conference on the subject. Subsequent acts reaffir
attitude. The history of the monetary conferences of 1878 and 18
miliar. Failing of immediate success in one sense, they exerted,
exert, influence as a means of educating the nations to work t
They remain a power, also, through the literature they called in
ence, including their reports, repositories of knowledge, which ha
gratuitously distributed throughout the world.

In Europe the issues connected with the proposal of the Unite
have been the object of thoughtful study, and the occasion of a wid
revision of economic doctrine in which earnest representatives of
icy of the conferences have taken an important part.

The present paper is the latest of a close succession of works f
same author bearing upon this question. It deals with the central
interest and of debate, which unite or engage all who think or spea
silver question. Indeed, the parity of silver and gold makes up
sense the sum of the whole matter. Monetary controversy since t
of 1873 is, in fact, but a story of parity, a question of parity once
and of its loss—about 1873. When is it to be regained? Accordin
delegates of the United States (of 1878 and 1881), it is to be regain
England shall be converted to see her own interest, and join the o
tions in restoring it. When this occurs the number of great po
quired to make the alliance for intermetallic parity will have been n

It thus appears that the question addressed to Mr. Horton pro
hearing of argument on the main issue, before a court of high juris

*Is it clear that the power of government goes to the extent of enabli
to establish a stable ratio between silver and gold?*

In his affirmative answer, the writer puts aside, as trivial and vi
reasoning which the public has been wont to hear reiterated in su
the negative. Much of this reasoning, it appears, grows out of c
between the economic and the political sides of the question. His
tive applies to the question, as an economic question, and is stated
of the law of supply and demand. Parity, he says, is the inevitab
of a wise regulation of demand operating upon a limited supply. T
ply of gold and silver is limited by their nature; what is needed ar
priate laws of nations to regulate their relative demand; that is
laws which give equality to the metals in their character as money
ity of legal privilege. Let the chief nations—including England, u

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advice of the royal commission — adopt these laws and the thing is done.

The only directly opposing arguments, to which the writer gives attention, are those which tend to "conjure up in some minds a mirage about the limits of supply." These arguments, he avers, belong to the order of gratuitous prophecies. The annual increment of the stock of silver and gold *always has been* a minute fraction of the stock already in men's hands: and there is no ground for supposing it *will be* anything more.

He then approaches his main theme which relates to the point of clearness. "How does it come to pass that doubt can exist on a point so simple and so clear as that parity can be so produced and maintained."

The doubt has existed in great force, and still exists in some measure. Why is this? There must be some cause at work to blind the minds of the learned, so that evidence and argument, such as that already adduced, are not appreciated.

It is all the more strange that doubt should exist when we observe its habitat. England, for example, is the scene of a series of remarkable parities. Ample instances of limited supply and of legal regulation of demand are in sight in England. Parity extends from bronze pennies to silver shillings, gold sovereigns, small notes, large notes and bullion. Nowhere is there a breach of the parity. And yet the doubt exists about the possibility of parity between silver and gold in spite of the fact that the very basis of discussing that possibility is a proposed legal regulation of demand, which shall be coëxtensive with the larger field in which the money metals are used.

What is the source of this doubt? It must be traced in the teaching of the leaders of economic thought; there must be a fashion of incorrect thinking about money and monetary laws and about the demand they regulate. Hence the review of the ideas of Adam Smith, Ricardo and Mill about parity.

They wrote while silver and gold were equally money, while phenomenal intermetallic parity was maintained by equalizing laws. But no effort had been made to ostracize one of the metals, and hence they were not imperatively summoned to investigate the cause of this parity. They omitted to investigate the question. They took silver and gold for what they were worth, without curiously asking the why and wherefore. Hence certain flaws in their teaching. In their action as political advisers about money, they were in a general way well disposed to both metals. But in their doctrine, in the monetary department of their systems of economic knowledge, defects appear. There is a lack of cohesion or junction between parts. The principles of monetary law, the nature of the institution of money, are slighted; and it is from this standpoint alone that the phenomenon of parity can be understood.

These defects are a natural outgrowth of circumstances. Modern economy arose as a reaction against an earlier system of economic learning, which is known since Adam Smith's day as the Mercantile or Commercial System. The central idea of this system was that national wealth consisted in national money; the important thing was, not the capital and the labor, not the savings and the skill of the citizens, but the cash they held.

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This being the ancient view, it appears that gold and silver were, so to speak, in the very citadel of that doctrine of state interference, which Smith and his successors sought to overthrow and destroy. By a natural exaggeration all monetary law was drawn into the struggle, and a certain neglect of it, or even antipathy for it, was generated, which extended itself to the present day. In earlier days little practical harm came from this neglect; the thinker's good sense being a safeguard against the error of his theory. The harm came when disciples proceeded to build their schemes of governmental action upon the oversights of the masters.

It is this process which the writer seeks to expose and to check.

In a critical review of representative passages (of the works, especially, of Ricardo and Mill) the writer presents evidence of the defects thus pointed out. These evidences are brought in contrast with what he has from time to time advanced as the main generalization upon which amendment of the doctrine of the older economist must be based. The tendency in the past has been to dwell exclusively upon one phase of money, namely Voluntary Payment, while what he names the Institution of Obligatory Payment has to an important extent been ignored. Yet the latter, he avers, is as it is always has been, a vital factor in civilization; the power of the state to establish and regulate money is a power always essential to the life of the state. It is because they lacked this legitimate foundation of principle that the accredited systems of knowledge about money, as set forth in economic treatises, have been largely infected with the unpractical or the visionary. They are, as it were, honeycombed with metaphors.

Witness the popularity of the fallacy "Trade in Barter," or of the deceptive analogy between the pound sterling and the pound Troy or the imperial gallon.

This flaw in economic theory has tended to incapacitate the mind from accurately weighing the evidence and argument which establish the certainty that parity of the metals can be maintained by concurrent laws of nations. But for the little that remains of this unpractical and visionary element among the representatives of science the economic question is everywhere settled.

The political question remains. But it must no longer wear the robes of science; it must appear in its proper character as a political question.

Will the leading nations of Europe pass the laws, the principle of which the United States proposed for their consideration in 1878 and 1881? Upon this question the world awaits the action of the British Royal Commission on Gold and Silver, and of the British Parliament.

THE FOOD SUPPLY OF THE FUTURE AND THE DOCTRINE OF MALTHUS. By Prof. W. O. ATWATER, Middletown, Conn.

[ABSTRACT.]

THE current ideas, area and soil production are based upon agricultural experience. Modern science is showing that the fertility of the soil as ordinarily tilled is not the necessary limit of its capacity to produce plants.

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This latter is really conditioned upon the supply of plant food and of water which reduces itself to the questions of the supply of energy for the transport of plant food and water and that of nitrogen as plant food. The indications are that with increased density of population there will come increased utilization of energy and of atmospheric nitrogen and that the production of plant food will be adequate to the demands of the race for the indefinite future.

THE AGRICULTURAL SURPLUS. By J. R. DODGE, Washington, D. C.

[ABSTRACT].

A DISTINGUISHING peculiarity of the United States is that it is a country of surplus. It has a surplus of productive resources in soil and mine, in invention and enterprise, in self-reliance and self-assertion. It has a surplus of national revenue without the consciousness of burden, and, of late, almost without a prospect of reduction. There is also a surplus of rural production in larger proportion to total volume than that of any country in the world. It is an element of strength and weakness, and, at the same time, is a subject for congratulation and regret. The congratulation is found in ability to relieve the deficiencies of needy nations while swelling the plethora of domestic wealth; the regret is for the tendency to overproduction of certain crops, and its inevitable result. This is the reduction of prices for the benefit of the foreign purchaser without any advantage to the producer. Very few people know the extent of our net surplus in agriculture. Almost every one exaggerates it. An Ohio economist and politician once said that for a quarter of a century, one-fourth of the products of agricultural labor of the United States have been exported. It was an absurd and grotesque misunderstanding, and yet it has been repeated on the floors of Congress. The real proportion is about one-tenth. The error arose from two causes. The sum of production was taken from census tables, that give little else than the results of arable culture, not including the meats and many other articles, and it was only about sixty per cent of the true aggregate of production. But this blunder was not the only one. The value of the product is that of farm prices, while the exports are reckoned at export prices, the value at the seaboard, and not that of the farms. While the export value of this surplus exceeds $500,000,000, it was actually worth to the farmer less than $400,000,000. This is the size of the surplus. But there is another side of the question. There is a deficiency as well as a surplus. Suppose we take the latter from the former and find the net surplus; find what remains after paying for food and drinks which we obtain from other lands. The imports of 1886-7 amounted to $287,542,266. This was foreign value, to which must be added the cost of transportation, commissions, and profits to obtain the value on our shores, which must be something like $350,000,000.

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Thus we have a surplus sufficient to pay for our deficiency, and little more. This is the net result of our boast of feeding the nations. We feed them just a little more than they feed us. The lesson we learn from these facts is that no nation can afford to have a deficiency of the raw products of agriculture, and as a rule, nations do not. There is one notable exception, and that is more apparent than real. Great Britain seems to have a large deficiency. Really, it is largely made good by shipments from her own colonies of the dividends of her own capital under the technical name of imports. Our agriculture, therefore, should seek to supply deficiencies rather than to swell surplus crops; to meet the present wants of domestic markets and create new wants by a greater variety of edible products, especially the fruits, and afterwards supply any deficiency of foreign nations that is practicable or possible.

THE NICARAGUA CANAL: ITS GENERAL FEATURES AND THE RESULTS ANTICIPATED FROM ITS CONSTRUCTION. By H. C. TAYLOR, Commander U. S. N., 34 Wall St., New York.

[ABSTRACT.]

IT is now a year since you were last addressed by us on the subject of the Nicaragua canal. Soon after the adjournment of your meeting of 1887 our company began the preparation and outfitting of a surveying expedition, the work of which, now complete, has been of the most careful and detailed character. I believe no large enterprise has ever been approached and prepared for with more careful attention or in more minute detail. While this expedition has been achieving excellent results in Nicaragua, preparation has been actively carried on in this country and Europe, and the interest aroused has been correspondingly great and widespread. There is, therefore, much that is new, both in the engineering features and in other aspects of the enterprise, which should, we believe, be brought before the association.

The late Mr. E. G. Squier, author of a well-known work on Nicaragua, adopted this line from Ovid for the title-page of his book, as a poetic characterization of the Nicaraguan route for an inter-oceanic canal:

Hic locus est gemini janua vasta maris— "This place is the vast gate of the twin sea." The image is a very happy one. Here the great *cordillera* which traverses the American continent from end to end sinks to its least elevation in the valley of the San Juan River. Between these mountains, bearing southeast from the Honduran frontier, and the coast range, skirting the west shore, of which Mr. Squier makes mention as "the undulating hills and ridges of land which intervene between the Lake and the Pacific,"— a basin is formed covering an area of 2600 square miles. This is the Lake of Nicaragua, one hundred miles long and forty wide, and, in places half a hundred fathoms deep. It drains a watershed of 8000 square

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miles and has a mean flow of 1,272,153,600 cubic feet per day. From east to west along the sailing line of the proposed inter-oceanic canal it carries a channel deep enough to float the largest ships. Its level is a little more than one hundred feet above the ocean, and is subject to no material variations. Some of the streams falling into it from the north are of considerable size, and furnish a supply of water, in excess of evaporation, which could not be sensibly affected by drains for artificial purposes.

The San Juan River, flowing into the Caribbean Sea, is the only outlet of this great Lake. Together the lake and river will form more than three quarters of the total mileage of the canal. The utilization of natural basins and the creation of artificial ones, in the valleys of the San Francisco, the Tola, and the Deseado, will afford such additional free navigation as to leave little more than one-sixth of the total distance to be excavated in order that this "vast gate of the twin sea" may be thrown open to the ships and the commerce of the world.

The axis of the San Juan valley is nearly east and west. Across this depression and along the route of the canal the trade-winds blow almost throughout the year, favoring the entrance and exit of vessels, ventilating and drying the land, and lowering the temperature. The Atlantic slope of Nicaragua is densely wooded, which keeps the ground comparatively cool. Here the warm winds, having their temperature suddenly reduced, deposit their moisture. Over the lake basin, and the dryer country on the west, their temperature is raised, and instead of depositing they take up moisture. Hence the difference in climate between the east and west sides, — the latter being almost rainless from November to May. The sky is usually cloudless during this dry season, and trifling showers fall only at rare intervals.

The temperature of Nicaragua is equable. Observations of the thermometer for eight months from July to March showed a maximum of 87° and a minimum of 71°. The extreme variation is about 20° and the mean variation about 10°. The effect of the dry season has been likened to that of a northern winter, checking and destroying the ephemeral vegetation which is continually renewed where rains are constant. During more than six months that the recent canal survey was prosecuted, the entire force, numbering nearly 200 men, enjoyed remarkable immunity from disease of every kind. The most and the hardest work was on the eastern division, in the valley of the San Juan, or that portion of the line which might have excited apprehension on account of the heavy rainfall and the alluvial soil. A powerful modifying influence on this river is the circumstance that the great expanse of Lake Nicaragua makes rise and fall very gradual, and as the river is only an outlet of the lake, and receives no tributary of consequence above the San Carlos, it is not subject to floods and sudden changes of level, which might leave conditions favorable for the development of malaria.

The line of the proposed canal will lie entirely within the boundaries of Nicaragua and Costa Rica, and the people and governments of these Republics show a keen and active interest in the progress of the undertak-

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ing. Guatemala, San Salvador and Honduras are also awakening to the fact that an enterprise of momentous import to their welfare has been inaugurated. Contractors experienced in the construction of public works in Central America have given the assurance that thousands of natives, accustomed to the climate and amenable to discipline, can be obtained for the construction of the canal when required. The recent experience of its engineers, with native laborers and men from the West Indies, has demonstrated that the labor problem will interpose no obstacles to the progress of the work.

Suitable timber, stone, lime, clay, sand and gravel for construction purposes abound along the line of the canal. With palm leaves for thatching, temporary shelter can be anywhere improvised in a short time. The cane huts of the natives are admirable for ventilation and for the coolness of their thatched roofs. More substantial structures can be erected according to the necessity for their permanency, at little other expense than that of handling the material. The country affords a supply of all necessary provisions,—beef, poultry, rice, beans, coffee, chocolate, sugar, fruits, vegetables, etc., so that little else than tools and machinery need to be imported for the work.

Such is the location of the projected ship canal from Greytown to Brito, and such the natural conditions along its immediate line of route. The engineers' estimates of the cost of construction include the electric lighting of the canal, the lighting and buoying of the harbors and the lake, and railroads from the lake to the Pacific and from Greytown to Ochoa, which, with lake and river, will form an immediate transisthmian connection and furnish facilities for communication and for transporting material during the period of construction.

The survey, the results of which are now in our possession, was not a preliminary nor an experimental one. It was an exhaustive scientific examination of a definite line, and the result has been referred to by the leading engineering journal of America as "a more accurate topographical map of that part of Nicaragua than exists to-day of the State of New York, excepting Coast Survey maps." All difficult portions were cross-sectioned at intervals of 100 feet, and all of the work was plotted on a scale of 400 feet to the inch, with 10 feet contours. As is well known, the Nicaragua route has been surveyed repeatedly in past years, so that the work of location just completed was performed under most favorable conditions for thoroughness and accuracy. The route itself was approved, during the presidency of General Grant, as the best and most practicable known route for a ship canal through the American Isthmus, by a Government Commission consisting of the Chief of Engineers of the United States Army, the Chief of the Bureau of Navigation, and the Superintendent of the U. S. Coast Survey, after a technical examination extending over several years, of the whole subject of inter-oceanic communication.

A contract was entered into in April, 1887, by the republic of Nicaragua with an association organized in New York, which secures to the latter exclusive right of way for the construction of the canal. A bill to incor-

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porate the "Maritime Canal Company of Nicaragua," for the purpose of carrying that contract into effect passed the United States senate in February of this year, by a vote of thirty-eight ayes and fifteen noes. In reporting this bill favorably to the House of Representatives, the Committee on Commerce said: "The association asking Congress for a charter has secured from the Government of Nicaragua a most liberal concession, allowing a period of two years and a half within which to commence operations, a grant of a million acres of land, and immunity from taxation, imposts and duties for a period of ninety-nine years. . . . Your Committee is fully satisfied as to the financial standing of the Association."

If to-day the canal were open for the passage of ships, it is estimated that four-and-a-half million tons of traffic would be ready at once to avail of it. M. Paul Leroy-Beaulieu, the eminent French political economist and statistician, in an article published in February, 1888, placed at that figure the traffic between the Atlantic and Pacific oceans, within the zone of attraction of an American inter-oceanic waterway. Of this amount, statistics of the three great ports of San Francisco, Callao and Valparaiso, for the year 1885, alone showed a total of two-and-a-half million tons. Official figures of the Bureau of Statistics of the U. S. Treasury Department and harbor returns of the free ports of Panama and Colon, the termini of the trans-isthmian railway confirm M. Leroy-Beaulieu's estimate with remarkable exactness. The tonnage of the ports of Colon and Panama amounted in 1885 to 1,217,685 tons. For the year ending June 30, 1887, according to the U. S. Bureau of Statistics, the trade of the Pacific ports of the United States with home and foreign ports on the Atlantic was 1,025,557 tons. For the same period the trade between Atlantic ports of the United States and foreign countries west of Cape Horn was 752,585 tons. Statistics of Great Britain, Germany, France, Belgium, Holland, Italy, and Spain (those of Russia, Austria, Denmark, Norway and Sweden not being available), place the trade of those countries around Cape Horn in 1886 at 1,471,899 tons, and the trade of British Columbia with Europe in 1886 was 39,818 tons.

The total is 4,507,044 tons. The existing traffic within the zone of attraction of a canal through the American Isthmus may therefore safely be stated at this amount, whereof more than half is commerce of our own Atlantic and Pacific ports. The Suez Canal was opened in 1869, and its net tonnage in 1870 was 436,609 tons. In 1883 it was 5,775,861 tons, and receipts of a million dollars the first year were swollen to $13,702,413. It is true that the business of 1883 was the high-water mark for the Suez Canal and that its traffic has not maintained the previous rate of development. But that state of things results from facts and circumstances which increase the favorable outlook of the American canal when compared with its Egyptian forerunner. In 1883 the Suez traffic reached the limit of the canal's capacity, and began to be seriously delayed by the inadequate dimensions of the passage-way and the insufficient number of the turn-outs. The depth was twenty-six feet and the width on the bottom seventy-two feet, the surface width varying from 190 to 330 feet. Vexatious delays,

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due to the grounding of vessels in turning the sharp curves and in going in and out of the sidings, interfered with the traffic so much and so often as ultimately to arrest its growth. The matter became so serious that a second canal was proposed by the British ship-owners, and the Suez Company was compelled to begin operations for deepening and widening the channel, and these are now in progress. The depth and the sectional area of all except a small portion of the Nicaragua canal will considerably exceed those of Suez, while in the lake, the San Juan river and the basins, its width will permit vessels to pass each other at their ordinary sea-going speed. Of the canal in excavation, all except a short stretch between the locks and in the rock cut, will have such width that vessels in transit can pass each other without inconvenience. The capacity of the canal will be at least twenty million tons per year, and could be doubled, if necessary, by duplicating the locks.

Another element which restricts the growth of the Suez Canal traffic is that it is limited to steamships. The physical conditions and erratic weather on a part of that route preclude its use by sailing vessels. Its development, therefore, is influenced in some measure by the fluctuations and exigencies of the business of ship owners and ship builders, for it is certain that a large part of the worlds' commerce is still carried by sailing ships. It is also true that in a measure the characteristics which close the Suez route to sailing ships render it undesirable for certain classes of steam-using vessels, navigating economically rather than with speed, or fitted only with auxiliary steam power. The Nicaragua Canal, on the other hand, will be admirably adapted for sailing ships and freight steamers. The trade-winds are most favorable to navigation in the Atlantic and the Caribbean Sea in the very latitude of its eastern entrance. Its western extremity lies in the same favoring belt, to the north of and entirely free from the calms and "doldrums" which vex the mariner in the region of the Panama isthmus.

The factor of the greatest importance, however, in influencing the growth of traffic, *via* Nicaragua, has no analogue at Suez. That is the certainty of the early and rapid peopling and building up of the territory served by the Nicaragua Canal,—especially the part lying within the United States. The commerce between Europe and the settlements, colonies and countries of India, Malaysia and China had reached a high state of development long before the Suez Canal was projected. It is doubtful whether that commerce is now increasing at all, and in any event its future growth must be at a very moderate pace. The natural development of our own Pacific states and territories, even at their present rate of progress, would soon furnish thousands of tons of traffic for the hundreds that now exist. The wheat, lumber, wool, fruit, hops, fish, oil, furs and mineral products of that virgin and imperial domain are just beginning to attract attention in the world of trade and finance. Its 100,000 square miles of the most available timber known to commerce, lying easily accessible from the ocean, have scarcely been looked at from the outside by the capitalists and merchants who before very long will be planting their

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mills by hundreds in the hearts of those forests. The acreage and product of the wheat fields of Oregon and Washington have doubled in the past ten years, and there is enough vacant land there to permit the same phenomenon within the next decade.

Less than twenty years ago our first transcontinental railway was opened. Five great systems now rib the continent with their main lines and branches, and another twenty years will, in all probability call as many more into existence. Who shall measure the stimulating effect upon our commerce and that of our near neighbors to the southward, of the safe and sure progress of an inter-oceanic canal, in American hands and under American auspices, toward speedy completion? Who can estimate the quantity of the tonnage that will pass through that canal twenty years from the day of opening? The traffic which now exists assures a profit upon the cost of its construction, even were that cost estimated at double the amount of the engineers' figures. Half of that trade enriches our own producers and merchants, but they maintain it against foreign competition under overwhelming disadvantageous conditions, which the canal would largely neutralize and in some conspicuous instances entirely reverse.

A map of the world will show Liverpool and New York to be about the same distance from San Francisco by the way of Cape Horn. The actual mileage is, from New York 14,840, and from Liverpool 14,690 miles. The saving, by the canal, between places near its western extremity and our Atlantic Gulf ports, will be so great that it is difficult to understand how it could fail to result in turning the entire trade of those ports, which now goes to Europe, into our markets. Callao and Valparaiso, which will be, respectively, 3,000 and 4,000 miles from New Orleans, will be 6,461 and 7,448 miles from Liverpool by the shortest route, — the canal. It would seem that such conditions must necessarily result in breaking down the artificial trade routes and relations which now exist and turning the commerce of these neighboring countries into more convenient and natural channels.

The opening of the Nicaragua canal will mark a great epoch in commercial history and progress. New and better routes and connections will be at the service of North and South and Central America, Mexico, China, Japan, New Zealand, Australia and the Pacific Islands. Their development will be quickened and its tendency shaped by these new relations. Intercourse between distant parts of the world will be cheapened and facilitated. The two great branches of the Anglo-Saxon race will meet in friendly rivalry on the Pacific, and spread yet farther abroad the language which ultimately is destined to regulate the commercial transactions of the entire globe. Our own commerce must increase notably in extent and importance. Coasting traffic between the Atlantic and Pacific doubtless will expand to enormous proportions. The ports of the Atlantic and the Gulf will send their regular lines of vessels and their occasional traders up and down the Pacific coasts, just as they now send them into every harbor and river and lagoon of the Caribbean and the Gulf, exchanging our commodities for the products of the tropics, until ultimately the hold of Europe upon the

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trade and commerce of Spanish America will be broken by the natural growth and influence of intercourse between the various countries of our own continent under most favorable conditions. Direct, speedy and inexpensive water transportation will put an end to the isolation which has so long retarded the development not only of the Spanish states of the west coast, but of our own magnificent territory bordering on the Pacific ocean.

Unless I greatly overestimate its bearing and effects, the forward stride about to be taken in the march of the world's commerce is to be a mighty one. When Byzantium was the glory of the Lower Empire, her merchants gathered the precious commodities of the East and sent them across the Mediterranean. Venice seized the inheritance, and for a long period maintained her position as the great entrepot of the eastern trade. After a fierce struggle, Genoa wrested from her the commercial supremacy and established herself as the western mart of this rich traffic. Still westward, from Genoa to Cadiz, and Lisbon, and Antwerp and Amsterdam, the great receiving and distributing centre shifted with the march of the ages, until finally the movement seemed to halt in England, and now for centuries London has been the commercial heart of the world and the controller of its exchanges. Nor is it strange that long preparation should be necessary for the next great westward stride, for it must cover a distance of 3,000 miles. It is this huge leap, well prepared for by the commercial strength and solidity of the lusty young nations of the Western continent, that is to be made by the opening of the Isthmian ship canal. The products that have hitherto gone westward to their markets will now go toward the east, while the manufactures of Christendom which have so largely gone east will now move westward. The step will indeed be a long one, and the revolution in the peaceful paths of trade throughout the world will be unique.

We of the United States can await this impending revolution with equanimity, for, much as it will help the world at large, it will most of all richly benefit the American continent.

NOTE.—This paper was in a good measure prepared by Mr. J. C. Hueston, of New York; based, in part, on suggestions given by Commander Taylor, but, in part, entirely original with Mr. Hueston.

RECENT NICARAGUA SHIP CANAL SURVEYS. By Civil Engineer R. E. PEARY, U. S. Navy, Washington, D. C.

[ABSTRACT.]

A YEAR ago I had the honor of addressing the Association upon this grand subject.

Seven months of the time intervening since then I have spent in Nicaragua with a large force of engineers and laborers, engaged in making surveys, the result of which I have the honor of presenting to you to-day.

These surveys, executed upon general plans formulated by Civil Engi-

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neer A. G. Menocal, U. S. N., who can justly lay claim to being called the evolutionist of the Nicaragua Route, have given more than satisfactory results, and I am able to lay before you plans and profiles based upon information as complete and accurate as any upon which a work of similar magnitude was ever commenced.

These results are due first to the master mind who planned the work, and whose extensive previous experience in that country made every day's work of the recent expedition effective, and second to those fearless, hard-working engineers who in spite of obstacles and hardships of which you have no conception, cut their way through the tropical tangle until they knew the shape of every hill, the course of every stream.

The methods of work were as follows: the expedition being divided into parties and the work into sections, the locations of Mr. Menocal in 1880 in the western division, and of the government expedition of 1872–73, and Mr. Menocal in 1885, in the eastern, were taken as a base, and a main transit and level line run and bench marks established about every 1000 to 2000 feet. These benches were then checked. From this transit line, compass, chain, and aneroid, offsets were run from 1000 to 2000 feet on both sides, adjacent streams, valleys and hills reconnoitred; and the work plotted.

With this chart in hand the entire line was then gone over in the field by the engineer in charge accompanied by the chief of the section, and the location decided upon. The location was then run in and levelled, checking upon the benches of the preliminary line, and cross-sections run and levelled from 100 to 400 feet apart, along the main line as the topography demanded. Sometimes portions of this location were modified and re-run.

Streams were then surveyed and gauged, neighboring elevations beyond the limits of the canal taken with the aneroid, and the entire work plotted on a 400 ft. scale with 10 ft. contours.

The boring party then went over the line, boring on all summits and in all depressions, and penetrating to the level of the canal bottom unless rock was encountered above that level. Borings were also made on the sites of all locks, dams and embankments.

The work accomplished by the expedition is as follows:

In the western division two locations, one for a canal in excavation the entire distance from the Lake to the Pacific, and one for a canal with a basin at La Flor.

Survey of Brito Harbor, and of the Lake in the vicinity of the mouth of the Lajas.

In the eastern division — survey of the Lake from the mouth of the San Juan to deep water.

Re-survey of the Upper San Juan from Fort San Carlos to Castillo.

Two locations from the Ochoa Dam to Greytown; one surveyed by the government expedition of 1872–73, and known as the lower route; the other surveyed by the government expedition of 1885, and known as the upper route.

Re-survey of Greytown Harbor.

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In all, the expedition cut, ran with transit, or compass, and levelled, 500 miles of lines, and ran 400 miles of soundings.

The first location in the western division, above mentioned, is practically the same as that of 1885, the only changes being such as would naturally be expected as the result of a final detailed survey, viz.: reduction in length from 17.27 to 17 miles; enlargement of the minimum radius of curve from 4000 feet to 4911 feet and reduction of total length of canal in curve.

In the second location the entire plan of the western section of the western division is changed as follows:

Three and one-half miles back from Brito, an earthen dam seventy-five feet high and 2,100 feet long on the crest, is thrown across the narrow gap in the coast hills through which the Rio Grande makes its exit to the Pacific. This dam will impound the drainage of the Rio Grande and Tola basins, and the water of the Lake, flowing through the summit cut; flood these valleys to the level of the Lake and form a basin 5.28 miles long, with a depth of water of from 30 feet to 70 feet. At the northern end of the dam a double lock of 85 feet lift effects the descent from this basin to the low coast land, and the canal then runs in a right line to the Port of Brito three miles distant, a second lock of 25 feet lift one mile from the double lock, dropping the canal to the sea level. This basin will be the harbor of the Pacific terminus and looking back from a steamer's deck as she emerges from the upper lock the port of Brito is visible just below, and beyond, the view of the blue expanse of the Pacific is unobstructed from north to south. From the eastern end of this basin to the lake, the two locations coincide.

The total distance from Lake to Pacific is not affected by this modification, but 5.28 miles of lake navigation are substituted for an equal length of canal; the length of actual canal is reduced to 11.72 miles; one lock is dispensed with; the problem of the disposition of the Rio Grande drainage is much simplified, and that of the Tola eliminated entirely.

The middle division, comprising the lake and river, remains unchanged.

The Ochoa dam may be constructed as proposed in 1885, viz.: a timber sheathed concrete monolith, or upon further study of the data obtained by the last surveys, it may be made an earthen dam and the overflow weir cut in the solid hills on the south side of the San Juan opposite the mouth of the Machado, thus removing the river current still farther from the entrance to the canal.

In the eastern division also, as already noted, there are two locations.

The one known as the upper route is identical with that of 1885 for a distance of four miles eastward from the Ochoa dam.

From this latter point to the Saltos de Elvira, a distance of eight miles, modifications have been made, though the general plan is unchanged.

The long embankment proposed in 1885, across the main valley of the San Francisco below the junction of the Chanchos, is replaced by five shorter ones about 1700 ft., 1200 ft., 1400 ft., 1700 ft., and 1200 ft. in length, respectively, across the valleys of the Chanchos, San Francisco, and tributaries, and there will be some 12000 ft. of secondary embankment at various

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points along the crest of the impounding ridge, with a depth varying from five to thirty feet.

The sailing line is shifted farther north, and the flooded area in the San Francisco basin reduced.

The rock cut through the San Francisco-Deseado divide is practically unchanged.

The lift of lock No. 3 at the eastern end of this cut is, however, reduced from 53 to 35 feet. This change, in combination with a dam and a second lock of 40 feet lift farther down the Deseado Valley, gives a basin of 3.84 miles long and with a depth of water of from 25 feet to 40 feet, requiring excavation to an average depth of 2 to 3 feet along the upper half (1½ miles). The dam just mentioned is 750 feet long on the crest and 40 feet high, and is in a very favorable location, affording an excellent site for the forty feet lock in the hill which forms the south abutment of the dam, and an equally favorable site for the waste weir beyond the northern extremity of the dam.[1]

From lock No. 2 to lock No 1, a distance of 2.70 miles, the canal still follows the axis of the widening and gradually descending valley. In this reach the level of the water in the canal will be a few feet above the average valley floor level, and a low embankment across the valley at the site of lock No. 1 will keep this portion of the valley flooded sufficiently to largely decrease ship resistance and enable the surface drainage to be received directly into it and discharge over a weir at the dam. Lock No. 1 has a lift of 31 feet and from it to Greytown a distance of ten miles, the canal, at sea level, extends in a straight line across the flat coast lands of the San Juanillo and Lagoon regions.

By these modifications in the Deseado Basin, not only is the amount of excavation in this division largely reduced, but the free navigation is increased and the lateral drains the entire distance from lock No. 3 to lock No. 2, a distance of 6½ miles, are rendered unnecessary.

The total distance from ocean to ocean by this route is the same as before, 169.8 miles. Of this distance, however, only 28. 9 (instead of 40.3) miles are actual canal, the remaining 140.9 miles being open navigation through Lake Nicaragua, the Rio San Juan and the various basins. The length of the summit level has also been increased from 144 miles to 150 miles.

The lower route is identical with the upper as far as a point about 2¼ miles east of the dam at Ochoa. At this point of divergence, either a single or double lock of 56 feet lift will lower the canal to within a few feet

[1] Since the above was written the locations of locks 3 and 2 have been changed as follows:

Lock No. 3 is now located on the site of No. 2 as above. Its lift is 45'. Lock No. 2 is located 2,570' farther down the valley and its lift is 30'.

The dam across the Deseado at lock No. 3 will be 820' long and 75' high.

As a result of these changes the Deseado Basin will be four miles long with a depth varying from 25' to 75', and its surface will be 106' above sea level instead of 71'. The length of the summit level will be increased from 150 miles to 154 miles.—R. E. P.

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of the San Francisco Valley level, and then the canal extends across this valley behind low hills lying nearer the San Juan, its level kept up by a low embankment about 15 feet high, supplementing the hills; towards the bend of the San Juan, where the San Francisco hills come to the river. From this point it extends in a straight line to the Serapiqui hills 6½ miles lower down the river, being kept up through this section also by a low embankment on the river side. In these hills the second lock of 20 feet lift is located, thence the canal extends to the San Juanillo, still following the general course of the San Juan, and thence in a nearly direct line to Greytown, through the delta of the San Juan, the Silico Hills where the third and last lock of 30 ft. lift is located, and Silico lagoon. The additional length of this route over the upper is 6.6 miles and with the exception of the portion through Lake Silico (1.53 miles) it is all canal in excavation.

Though based upon the location of 1872–73 it differs from that in the following particulars:

It is 3½ miles shorter.

It has about one-half the number of curves.

It has no curve of less than 6,000 feet radius, and can be located with none less than 10,000 feet.

Its disadvantages, as compared with the upper route, are greater length and consequently greater cost of maintenance.

Thus we have at Nicaragua two perfectly practicable locations of about equal cost, either of which is far superior to any other route across the Isthmus: and when the day comes, as it surely will, when one canal cannot accommodate the traffic seeking it, then the other can be built and give one canal for eastward, and one for westward bound vessels.

I regret that the computations of the notes of the recent surveys have not as yet been completed, and I am consequently unable to give precise quantities and estimates. But the close correspondence between the measurements of former, and the last surveys, enables me to say in general terms, that quantities in sections where no modifications have been made will be changed little or none, while the total saving by modifications of plan will amount to $10,000,000 or $15,000,000.

The value of the 25% contingent estimate is also greatly enhanced by the closer determination in the recent surveys of all factors in the problem.

Probably in no similar undertaking have the conditions for the rapid and economical execution of the work been more exceptionally favorable.

In the western division that portion of the canal from Brito to the first lock, and possibly from the first lock to the double locks, can be dredged.

The Upper Rio Grande will furnish water for the removal of the surface earth by hydraulic mining, and later for running the rock drills in the divide cut. The deeper portions of the La Flor basin offer convenient and ample room for depositing all the material from the divide cut not used in the La Flor dam, and it will not be difficult to devise a method by which the water of the Lake can be made to give powerful assistance in the work of excavating and removing the material in the cut between the La Flor basin and the Lake.

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In the eastern divide on the upper route exist similar conditions of water power available for removing surface earth hydraulically, and later for running air compressors for the drills. The deeper portions of the Chanchos and San Francisco valleys contain ample dumping ground for the spoils from the divide: and in removing these the engineer will have gravity with, instead of against him.

From Greytown to the first lock in the eastern section the excavation will be entirely dredging.

Probably not less than seventy-five per cent of the excavation between lock No. 1 and lock No. 2 also in the Deseado and San Francisco basins, and in the section from the latter basin to the dam, can by a proper sequence of work be excavated by dredges. On the lower route at least eighty-five per cent in length can be dredged, and the maximum haul of the earth and rock spoils on any portion of the remaining fifteen per cent will be about one-half mile.

The item of earth excavation, with all its varied plant of excavators, cars, locomotives, etc., its attendant expense of moving tracks and keeping tracks in order, and the difficulty of handling the material in rainy weather, is thus reduced to a minimum, and the excavation of the canal accomplished practically under the three great heads of Hydraulic Mining, Rock Excavation, Dredging, all three independent of drainage and rains, the great drawbacks to work on the Isthmus, and the work on the canal can be pushed forward without interruption night and day, year in and year out, until it is completed.

The numerous borings made have banished the bottomless swamps, the semi-liquid quicksands, and the numerous other subterranean bugbears which have been conjured up against the Nicaragua route, and have shown that in no portion of either location is there any trouble in regard to foundations.

In the worst swamps encountered, the boring tools after sinking by their own weight for a distance of ten, or at a maximum fifteen feet, reached a stratum of firm red clay extending to bed rock. The sequence of strata everywhere except in the San Juanillo region, is almost without exception as follows: in the low bottoms, black mud or loam; then varying strata of blue or red or yellow clay or sand, or both, or all; then firm red clay; then, if the borings were carried deep enough, rock; on the hills, red clay and earth to bed rock. The borings show the even and unbroken character of the rock in the divide, and have also developed the fact that the earth covering of the bed rock averages deeper than was supposed in 1885.

In the valley of the San Juanillo, sand is found mixed with soft blue and yellow clays, and nearer the harbor sand alone. Borings at Greytown bar and in the harbor to the depth of forty feet below sea level, discovered no rock, only compact homogeneous sand, and on the upper route no rock was discovered within ten and a half miles of Greytown nor on the lower route between Greytown and the Silico Hills. The borings also show rock foundations for all the locks and the Ochoa dam.

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LOCKS.

The locks in general dimensions and methods of construction remain the same as proposed in '85, viz.: 650 feet long and 80 feet wide.

The number, however, will be reduced from seven to six, and possibly five: the total lift will be somewhat differently distributed: a new feature is introduced in the shape of the double lock at the La Flor dam, and it is more than probable that improvements will be made by which the time of lockage will be reduced from forty-five minutes, as previously estimated, to thirty minutes. The gates proposed for the locks are sliding caissons for head gates and two tail gates, and rolling caissons for the other tail gates.

WATER SUPPLY.

The amount of water necessary for working the canal to its full capacity, viz.: forty-eight double lockages per twenty-four hours is 210,161,280 cu. ft. or less than one-fourth the minimum supply of the Lake alone (984,096,000 cu. ft.) without taking into consideration the flow of the several tributaries of the San Juan between the Lake and the Ochoa dam, and the San Francisco and its tributaries, which will more than compensate for all losses by evaporation in the flooded portion of the river, and the basins.

DIMENSIONS AND CAPACITY OF THE CANAL.

Some modifications of the cross-sections proposed in 1885 may be made, but for the present they may be assumed to be the same.

They will be ample to accommodate all the traffic that the locks can handle, and the capacity of the locks will be the measure of the capacity of the canal.

The maximum capacity of the canal was estimated in 1885 at 20,440,000 tons, based upon a time allowance of forty-five minutes for passing a lock, and the average net tonnage of the vessels using the Suez canal in 1883, viz.: 1747.

In 1886 the average tonnage at Suez was 1863 tons, and the constant tendency has been towards an increased average tonnage, which increase would have been much greater had it not been for the limitations imposed by the depth of only 26 feet at Suez and the insufficient facilities for vessels to pass each other.

With a depth of 30 feet at Nicaragua and considering the heavier class of traffic which would seek that canal, a conservative estimate would be that the average net tonnage of vessels using Nicaragua would almost immediately reach 2,000 tons or more.

With the probable improvements in the locks already noted, by which the time of lockage may be reduced to thirty minutes, the ultimate capacity of the canal will be forty-eight vessels per day of 2,000 tons each, or 35,040,000 tons annually.

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CLIMATE.

Much has been said both for and against the climate of Nicaragua, but the experience of the recent expedition is worth volumes. Over forty engineers and assistants, not half a dozen of whom had ever been in tropical countries before, and some of whom were college graduates, who had never seen a day of really hard work or exposure, went to what is by common consent, the most unhealthy portion of Nicaragua, viz.: the region extending thirty miles back of Greytown, started at once into the woods, before the rainy season had closed, worked in the rain and swamps all day, and repeatedly slept on the ground at night, and yet in all the seven months that the expedition remained in the field not a man was lost, nor was there a single case of serious illness. More than that, every member of the party that has thus far returned, has come back in better condition than when he went away. I myself have repeatedly spent several successive days and nights, the former in traversing the lines of the various parties, the latter in sleeping as best I could uncovered and in wet clothes in my boat, while my crew who had slept during the day, paddled along the San Juan or up the San Francisco or Deseado, and at the end of the trip felt as well as when I started.

This was due, partly to the fact that no pains were spared to supply the expedition with the best of everything in the way of provisions, and partly to certain regulations which were rigidly insisted upon, but more to the climate and equable temperature, in which a sound man, with the simplest precautions, cannot be other than well.

In conclusion, I am happy to say that it is not now a question as it was a year ago,—shall we build the Nicaragua Canal? but we will build it.

The last year has seen a great verdict in its favor. In 1876, the great International Canal Congress at Paris, resolved that if a canal with locks were to be built, then the Nicaragua route was the best, but as a sea level canal was a *sine qua non*, and as such a canal was feasible at Panama, Panama was the only place for a canal. To-day, preparations are being made to put in locks on the Panama route, and not five or six as at Nicaragua, but ten, and the summit level of a canal which is said to be intended to accommodate the traffic of the world, is to be supplied with water by pumping.

This is the age of ship canals. Whatever sophisms may be put forth against them, ocean commerce recognizes their economy and utility, and in response to its demand they are being built and will continue to be built until every path of ocean commerce is reduced to its minimum length. European nations are building them for purely local traffic or from political considerations. Within the year, England has commenced upon the Manchester Ship Canal, and is to-day removing earth at the rate of 1,000,000 cubic yards per month. Russia has completed the Petersburgh and Cronstadt Canal, and is projecting another (Sea of Azof). Germany has commenced upon the North Baltic Canal. France is at work upon the Corinth. Suez and Amsterdam are doing an annually increasing business. But greatest project of them all, pledge of incalculable benefits to ocean traffic and

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of commercial prestige to this country, is the Nicaragua Canal. It is the one grand link yet wanting to enable commerce to circle the globe without going beyond the limits of the tropical zone.

The gentleman who preceded me has covered the general bearings of the theme most eloquently, yet I cannot help trenching a bit upon his domain. The Nicaragua canal will bring every Atlantic port nearer every Pacific port; it will move the mouth of the Mississippi to the centre of the Pacific; it will give our western coast an impetus which will in a few years place it as far beyond what it is to-day as it is to-day beyond what it was when our statesmen were discussing the advisability of its purchase.

It will be a national stimulus to invention and with its great demand during construction, for men, machinery, materials and supplies, will offer a field for engineers, architects, machinists, contractors, business men, skilled labor of every kind, and a great market for supplies, which of itself alone will be of the greatest value to this country.

ON THE LIFE AND WORK OF E. B. ELLIOTT. By Mrs. L. O. TALBOTT, Washington, D. C.

THE TRUE BASES FOR DEALINGS IN MILLS. By HENRY E. ALVORD, Agricultural College, Maryland.

THE MONEY HOARD IN THE UNITED STATES TREASURY. By EDWARD DANIELS, Washington, D. C.

OUR MONETARY SYSTEM. By EDWARD DANIELS, Washington, D. C.

THE HISTORY OF STATISTICS AND THEIR VALUE. By WILLIAM F. SWITZLER, Bureau of Statistics, Washington, D. C.

CREMATION: PAST AND PRESENT; WITH DESCRIPTION AND DIAGRAM OF THE BUFFALO CREMATION COMPANY'S FURNACE. By CYRUS K. REMINGTON, Buffalo, N. Y.

INDUSTRIAL TRAINING FOR VAGRANT CHILDREN AND IMMIGRANTS. By Mrs. LAURA O. TALBOTT, Washington, D. C.

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ABSTRACT OF THE PROCEEDINGS OF THE CLEVELAND MEETING OF THE ENTOMOLOGICAL CLUB OF THE A.A.A.S.

THE Club met as per announcements, Aug. 15, at 9 o'clock, A. M., the President, Mr. JOHN B. SMITH of Washington, in the chair. The Secretary, Prof. A. J. COOK, being unable to attend, Prof. HERBERT OSBORN was elected Secretary for the Cleveland meeting.

Sessions of the Club were held on Wednesday, Thursday and Friday during hours when Section F was not in session. The following members were present: John B. Smith, Washington, C. V. Riley, Washington, L. O. Howard, Washington, D. S. Kellicott, Buffalo, N. Y., O. S. Westcott and Mrs. O. S. Westcott, Chicago, F. M. Webster, Lafayette, Ind., C. J. S. Bethune, Port Hope, Ont., James Fletcher, Ottawa, Canada, J. Mackenzie, Toronto, S. H. Peabody, Champaign, Ill., E. A. Schwarz, Washington, D. A. Robertson, St. Paul, Minn., A. B. Mackay, Agricultural College, Miss., S. B. McMillan, Signal, Ohio, L. C. Wurtele and Miss Wurtele, Acton Vale, P. Q., Herbert Osborn, Ames, Iowa.

The annual address by the President, J. B. Smith, entitled Entomology and Entomological Collections in the United States, was delivered on Wednesday afternoon and subsequently discussed by Messrs. Riley, Howard, Fletcher, Webster and Osborn.

Mr. James Fletcher gave an interesting account of collections and entomological work in Canada.

A note On the Origin of the Wing in Aleurodes was presented by Prof. Herbert Osborn and illustrated with microscopic preparations.

Papers by Mr. Clarence M. Weed were presented and discussed as follows:

On the Parasites of the Honey-suckle Sphinx, *Hemaris diffinis* Boisd.

On the Hymenopterous Parasites of the Strawberry Leaf-roller, *Phoxopteris comptana* Frōl.

Professor Osborn presented a paper, On the Food Habits of the Thripidæ.[1]

Dr. D. S. Kellicott presented a note on *Hepialus argentio-maculatus*.

Prof. Herbert Osborn presented a note On the Occurrence of *Cicada rimosa* Say, in Iowa.

Prof. O. S. Westcott in a paper entitled "Entomological Memoranda" presented notes On Attraction of Carrion for Butterflies; the coincident occurrence of varieties *marcia* and *morpheus* of *Phyciodes tharos;* peculiar place of pupation for an Agrotis (?); occurrence of *Lachnosterna fusca* and *gibbosa*.

Mr. L. O. Howard remarked upon experiments with kerosene emulsion for underground larvæ.

[1]Published in full in *Insect Life* No. 5.

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Mr. James Fletcher gave an account of an expedition to Nipigon north of Lake Superior and described methods of rearing butterflies from eggs.

Mr. E. A. Schwarz presented a paper entitled, The Insect Fauna of Semitropical Florida with special regard to the Coleoptera. This called forth a long discussion participated in by Messrs. Riley, Smith, Howard, Bethune, Fletcher, Peabody and Osborn.

The election of officers for the next annual meeting resulted as follows: *President*, JAMES FLETCHER, Ottawa, Canada; *Vice President*, L. O. HOWARD, Washington, D. C.; *Secretary*, D. S. KELLICOTT, Columbus, Ohio.

In accordance with a vote of the club the proceedings have been published in full in *Entomologica Americana* and all papers not otherwise indicated have been included in full in that report, which will be found in Nos. 6–9, Vol. iv, 1888.

HERBERT OSBORN,
Secretary of the Club for the Cleveland meeting.

ABSTRACT OF THE PROCEEDINGS OF THE CLEVELAND MEETING OF THE BOTANICAL CLUB OF THE A.A.A.S.

Wednesday, August 15. Meeting called to order at 9 A. M. The President, Mr. DAVID F. DAY in the chair. Rev. W. M. BEAUCHAMP was elected Secretary *pro tem.* in the absence of Prof. V. M. SPAULDING. The President opened the meeting by an address including a memoir of Dr. Gray and a recommendation that the Club be incorporated as a section of the Association.

Before the reading of the papers in the day's programme two motions were made and carried: one to the effect that the Secretary should be provided with a book for permanent records of the Club; the other, that a committee be appointed to consider the proposition in regard to uniting the Club with the biological section of the Association. As members of this committee the Chairman appointed Messrs. W. H. Hale, Thos. Meehan and J. F. Cowell.

It was also resolved that a committee should be appointed to provide for the publications of the proceedings of the Club. The committee appointed consists of Messrs. W. H. Seaman, W. H. Hale and Thos. Meehan.

Mr. Thos. Meehan read papers on "Dicecious Labiatæ," and "The Elastic Filaments of the Stamens of Compositæ;" and Mr. J. F. Cowell followed with "Observations on *Azalea nudiflora* and *Corallorhiza*."

Thursday, August 16. After the meeting had been called to order, the question of making the Club a special section of the Association, or else a sub-section of Section F, was discussed. The report of the committee was read, and in this they strongly recommended that the independent organization of the Club should be maintained. After further discussion, their recommendation was unanimously adopted.

The President then announced that an invitation had been extended to the Club, by Mr. J. D. Rockafeller, to visit his grounds. As, however,

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the time of the Club was already fully provided for, it was decided that the Club as a body could not set a date when it would be possible to accept the invitation, and on motion of Prof. C. R. Barnes, the regrets of the Club at their inability to accept the invitation were ordered to be transmitted to Mr. Rockafeller.

Mr. Thos. Meehan spoke of the death of Dr. Gray and suggested that resolutions ought to be adopted by the Club in reference to it, and the following gentlemen were appointed as a committee to draft such resolutions: Messrs. C. R. Barnes, Thos. Meehan and D. S. Kellicott.

Rev. W. M. Beauchamp read a paper on "Onondaga Indian Plant Names."[1] Mr. Beauchamp also exhibited specimens of *Erythræa Centaurium*, gathered near Oswego, a plant new to most of those present.

Mr. Thos. Meehan read a paper on "Irregular Tendencies in the Tubulifloral Compositæ."[1]

Prof. E. L. Sturtevant read a paper on "Observations on the genus *Capsicum*," accompanied by numerous beautifully executed colored drawings, showing the great variations in the fruit of different varieties. The author pointed out the difficulty of distinguishing species in plants that had been long cultivated, and expressed his doubts as to the validity of certain of the genus under consideration. Mr. Meehan expressed his interest in the paper, and said he was inclined to believe that all the cultivated Capsicums were merely varieties of a single species.

The last paper was by Prof. B. E. Fernow, on the subject "What is a Tree?" In the paper the author pointed out the desirability of a generally accepted definition of the word "tree," and showed how authorities differ in regard to it. The following definition was suggested: "Trees are woody plants, the seeds of which have the inherent capacity of forming a definite trunk supporting a crown of branches."

After a discussion of the paper, the meeting adjourned.

Friday, August 17. After some preliminary business, the following resolutions, in memory of Professor Gray, prepared by the Committee appointed for that purpose, were unanimously adopted:—

Resolved, That the Botanical Club of the American Association sincerely regrets that, meeting but once a year, it should be among the last to place on record the sense of the great loss which the whole range of science suffers by the death of Professor GRAY.

Resolved, That though among the last to contribute to the wreath of sorrow with which science is everywhere crowning the memory of Dr. GRAY, this body takes a mournful pride in remembering that he was one of its honored members, and that it was as a botanist he won such eminent renown. We feel that we have a right to be among the chief mourners at his departure from the field of labor he loved so well, and in a special degree to unite our sympathies with the many thousands who miss him everywhere.

Resolved, That copies of these resolutions be forwarded to the family of

[1] Printed in Bulletin Torrey Botanical Club, Oct., 1888.

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our deceased friend and to the botanical and other scientific periodicals for publication.

Papers were read by Prof. C. R. Barnes on "The Cause of the Acridity in the Corm of Arisæma," and by Mr. A. A. Crozier on "Secondary Effects of Pollination." Professor Barnes stated that it was probable that the intensely burning taste of the juice of Arisæma was due, as suggested by Stahl for the European *Arum maculatum*, to mechanical causes, *i e.*, the irritation produced by the numerous rhaphides with which the juice is filled. Professor Barnes found that when these were removed by filtering the acrid taste was completely lost.

Mr. Crozier's paper was read by Professor Cowell, the author being absent. From the author's experiments, mostly in different varieties of apples, he concluded that the influence of foreign pollen did not extend beyond the seeds.

Mrs. H. L. Walcott exhibited the leaves of a form of choke-cherry which she described as having amber-colored berries and much shorter racemes than the ordinary form.[1]

Prof. W. R. Lazenby brought up the question as to the distinctness of the two forms of Virginia Creeper, which was discussed at some length by several members.

A letter from Dr. Geo. Vasey was read on "American Desert Plants," after which the meeting adjourned.

In the afternoon the Club made an excursion to Brighton, a suburb of Cleveland, but the flora of the vicinity did not present many novelties. One of the most interesting plants found was *Jeffersonia diphylla*, of which fine specimens were obtained in fruit.

Saturday, August 18. The entire day was devoted to a trip on the steamer "City of Cleveland," to the Put-in-Bay Islands. The trip was such a long one as to allow but little time for botanizing.

Monday, August 20. The following papers were read: by Prof. Jos. F. James on "*Dentaria laciniata* and *D. multifida*;" by Mr. F. L. Scribner on 'Observations on Nomenclature" and "*Sphærella Fragariæ*;" and by Mr. Thos. Meehan, on "Peduncular Bracts in *Tilia*."

Professor James also exhibited a form of *Asclepias tuberosa* with flexuous stem and sub-opposite leaves, which he thought was sufficiently distinct to be regarded as a variety.

The committee on nominations of officers for the ensuing year reported in favor of Prof. T. J. Burrill, of Champaign, Ill., for President, and Douglas H. Campbell, of Detroit, Mich., for Secretary, and also recommended that the office of Vice-President be created, and named Prof. Byron D. Halsted of Ames, Iowa, for the office. The report of the Committee was accepted, and the officers as named were elected.

Tuesday, August 21. Prof. W. R. Lazenby read a paper on "The Flowering Plants of Ohio," and was followed by some remarks by Mr. David F. Day on those of the vicinity of Buffalo, and by Mr. Beauchamp on the Cayuga flora.

[1] Printed in Bulletin Torrey Botanical Club, Oct., 1883.

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Mr. F. Scribner read a paper upon and discussed the genus *Andropogon*.

Prof. V. M. Spaulding contributed a paper on "Changes Produced in the Host Plant by *Puccinia graminis*." The author being absent, the paper was read by Mr. D. H. Campbell.

Prof. M. B. Waite contributed a paper on "Changes in the Local Fungus Flora of Champaign, Ill." In the absence of the author, the paper was read by Mr. Scribner.

Prof. W. J. Beal read a paper entitled "Notes on some Flowering Plants of Michigan."

At the conclusion of the meeting the Club adjourned to meet next year in Toronto, Canada.

Besides the papers read before the Botanical Club, the following botanical papers were read in Section F of the Association: "A Plea for Uniformity in Biological Nomenclature," N. L. Britton; "A Study of *Hydrangea* as to the Objects of Cross-Fertilization," Thos. Meehan; "A Phase of Evolution," E. L. Sturtevant; "Notes on the Inflorescence of *Callitriche*," Jos. Schrenk; "Hygroscopic Movements in the Cone-Scales of Abietineæ," A. N. Prentiss; "Some New Facts in the Life-History of Yucca and the Yucca Moth," Thos. Meehan; "On the Cause and Significance of Dichogamy in Flowers," Thos. Meehan; "Adaptation in the Honeysuckle and Insect Visitors," Thos. Meehan; "Comparison of the Flora of Eastern and Western Michigan in the latitude of 44° 40′," W. J. Beal; "Observations on the Succession of Forests in Northern Michigan," W. J. Beal; "The Systematic Position of the Rhizocarpeæ,"[1] Douglas H. Campbell; "Pollen Germination and Pollen Measurements," Byron D. Halsted.

The following botanical papers were read before the Society for the Promotion of Agricultural Science: "Peculiarities of the Plants of Northern Michigan," W. J. Beal; "Notes on Flowering Plants of Ohio," W. R. Lazenby; "Potato Flowers and Fruit," Byron D. Halsted; "Tomato Flowers and Fruit," Byron D. Halsted; "A Further Study of the Dandelion," E. L. Sturtevant; "Successful Treatment of Black Rot," F. L. Scribner.

DOUGLAS H. CAMPBELL.

[1] Printed in Bulletin Torrey Botanical Club, Oct., 1888.

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EXECUTIVE PROCEEDINGS.

REPORT OF THE GENERAL SECRETARY.

THE THIRTY-SEVENTH MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE WAS HELD IN THE CENTRAL HIGH SCHOOL BUILDING, CLEVELAND, OHIO.

AT ten o'clock on Wednesday morning, August 15, the Association met in GENERAL SESSION in the large hall of the High School, and was called to order by President S. P. LANGLEY of Washington who invited the Rev. Dr. C S. BATES of Cleveland to open the session with a prayer, which was offered as follows:—

Our Father, who art in heaven, Hallowed be thy Name. Thy kingdom come. Thy will be done on earth, As it is in heaven. Give us this day our daily bread. And forgive us our trespasses, As we forgive those who trespass against us. And lead us not into temptation; But deliver us from evil: For thine is the kingdom, and the power, and the glory, for ever and ever. Amen.

We thank Thee, our Heavenly Father, for every revelation of truth which Thou hast made to the children of men. We pray that Thy blessing may rest upon every one who is seeking to know more clearly the meaning of any word of any of those revelations. But especially do we pray that Thou wilt bless the members of this Association and the work in which they are engaged. May the fruit of their labor be full of ministration to the needs of men; giving to their bodies fuller life and larger power, and to their souls a clearer vision of the greatness of Thy wisdom, and the glory of Thy love.

Direct us, O Lord, in all our doings, with Thy most gracious favour, and further us with Thy continual help; that in all our works begun, continued, and ended in Thee, we may glorify Thy holy Name, and finally, by Thy mercy, obtain everlasting life; through Jesus Christ our Lord. Amen.

The grace of our Lord Jesus Christ, and the love of God, and the fellowship of the Holy Ghost, be with us all evermore. Amen.

PRESIDENT LANGLEY, with a few graceful remarks, resigned the chair to the President elect, Major J. W. POWELL of Washington, who on accepting it said:—

Over this society you have called me to preside. For the honor you have conferred upon me I am most profoundly grateful. When I remember the great men who have presided over this body I am deeply sensible of the magnitude of the trust imposed upon me, and would gladly be relieved from its duties and would surrender its honors to purchase immu-

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nity from the ordeal through which I must pass, for I feel that I inadequately prepared to fill the position. It is with this feeli invoke your charitable assistance to secure for the deliberatio meeting that wisdom and harmony which will make the society fo year an effective agency for the advancement of science.

Dr. Cady Staley, president of the Case School of Applied Cleveland, was introduced and delivered the address of welcom half of the Local Committee as follows:—

It is thirty-five years since our citizens have had the privileg coming to Cleveland the American Association for the Advanc Science. During those years the advancement of science has b vellous. The discoveries and inventions within that time have the dreams of the wildest visionary who met with the society meeting in this city. For this rapid advance of science, in bot and practice, the world is greatly indebted to the members of t ciation. If there are any here of that company who met with ciation in '53 they will testify that the growth and developme city have not been less marvellous than has the advance of scie same period. Then there were in the city about 26,000 inhabitants there are about ten times that number, and to a large extent the its magical growth and wonderful prosperity to the advance of and its application in the arts and in manufactures. It would b to find a city in which a larger proportion of the inhabitants are i directly or indirectly, in pursuits which depend upon scientific and processes.

It is peculiarly fitting that this association of scientists shoul Cleveland—a city which owes so much to the practical applicati ence in various fields.

No guests can be more welcome than those whose time and t employed in forwarding interests of such paramount importance to

To our own citizens this meeting is an event of no slight im The value of such meetings in any community, in creating an i science and in scientific research, is not easily overestimated.

On the other hand, we trust that to the members of the As their coming to this city may not be altogether without profit. work of deducing scientific laws is of itself of intense interest, ly theoretical results are worth all that they cost in time and the practical application of scientific laws and theories has, for a jority of even scientific men, the greater charm. I doubt if th other city in this broad land where applied science in its var can be so advantageously studied.

To simply name the establishments which depend upon scientific and processes for their administration would weary your patienc often thought of what an opportunity there is here for some one gift of story-telling to write a modern version of the "Arabian which shall be told more marvellous things than Scheherazade

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the amusement of the bloodthirsty Sultan, and yet all strictly true. The most wonderful story in that book full of wonders is that of "Aladdin and his Lamp." According to the story, Aladdin had but to rub the lamp to summon the genie, who—to use the phrase of the old story teller— was "ready to obey him as his slave, the slave of all who hold the lamp in their hands." In short, the genie would do whatever Aladdin told him to. Aladdin had only to draw on his imagination.

And now having cut loose from all pretence of adhering to plain, unromantic facts, the story teller gives rein to his imagination, to see to what lengths his untrammelled fancy can carry him. In his wildest flights the genie of the lamp builds for Aladdin a splendid palace and furnishes it gorgeously; provides him with magnificent apparel and sumptuous banquets; brings him vessels of gold and silver, and jewelry of rare workmanship, set with costly gems. Now the point in which the modern version surpasses the ancient one is that all this has actually come true in Cleveland.

You can see on our streets splendid palaces produced and furnished by the slave of the lamp; and this same slave has brought enormous wealth, not to one only but to several modern Aladdins. Aladdin could summon the genie only by rubbing one particular lamp, and if some one else secured that lamp Aladdin could no longer control the genie. But in these latter days we can summon the slave by rubbing other things besides a lamp, and we have found out many ways of commanding the presence and service of the wonder-working genie. One of our Cleveland Aladdins employs a windmill for that purpose. Aladdin stood much in awe of the slave of the lamp, and called for his services only upon rare and important occasions. But we have grown more familiar with him, and have made him generally useful. He draws wagons, drives machinery, melts refractory substances, combines and separates chemical elements, produces light and heat at our pleasure, runs errands, carries messages,—in fact we could hardly keep house without him.

I can imagine a traveller from Cleveland walking the streets of a Persian city and falling in with one of the professional story-tellers, who still amuse the people of the East by spinning marvellous yarns of the "Arabian Nights" variety. The traveller listens to one of the Persian's stories and then proposes to tell one himself. He begins by stating that what he will tell will be a plain unvarnished tale of what could be seen any day in his native town, and not the wild flights of Eastern fancy. Then he tells of the manipulation of iron at the rolling mills, the steel works and the forges; of the marvels of mechanism turned out by Warner & Swazey; of the ingenious contrivances employed in the various factories; of the wonders wrought by chemical processes; of the work of the modern slave of the lamp — the electric lights and motors, the telephone and the phonograph. And, as the traveller proceeds, the expression on the old Persian's face changes from one of lively interest and astonishment to that of dejection and defeat. He feels himself completely outdone in narrating marvels. Then from the folds of his robe he draws and extends to the traveller an

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illuminated card upon which is inscribed in beautiful Persian characters—"I am something of a liar myself."

I need carry the idea no further. You can each write your own version of the "Modern Arabian Nights," and keeping strictly within the realm of accomplished facts as exemplified in this city, you may tell of more wonderful things than ever Eastern story-teller conceived in the wildest flights of his imagination. We hear about the triumphs of science until the subject seems trite, and yet no one man can fully realize all the wonderful things which have been accomplished in the many and varied fields of scientific investigation; the rapid advances of the present; or the possibilities of future achievement.

I look forward to this meeting of your Association for new revelations in the fields of scientific research; for help in once more getting abreast of the thought and work of the day; and for renewed inspiration in keeping step with the march of progress, and in doing our part in the rapid advance of science. The citizens of Cleveland are interested in the work of this Association; they are ready to do what they can to make this a successful meeting; and in their behalf I extend to you a hearty welcome.

It was expected that Mayor Babcock would deliver the address of welcome on behalf of the city, but in his absence the duty was admirably performed by the local secretary, Dr. ELROY M. AVERY. In the course of his remarks, he said: You have been charmed by this charming story of our city, but it is incomplete, for what is Hamlet with Hamlet left out? I am not the mayor of the city, but I am his humble and obedient slave. I give you welcome to this beautiful city in the name of its quarter of a million of inhabitants. In the name of the municipality, I bid you each and every one a cordial welcome to the Forest City.

President POWELL replied as follows:

In behalf of the American Association for the Advancement of Science, I give you most hearty thanks for the welcome you have extended to the society, and for the generous provision that the citizens of Cleveland have made for its meeting. It gives us great joy to meet in this beautiful city. Cleveland stands on a terrace fashioned by the ice of a continental glacier and the waves of an ancient lake, and is surrounded on one side by beautiful Devonian hills and on the other by crystal waters. We remember that here at Cleveland the waves of Erie beat in solemn rhythm against the grave of Garfield, the statesman and scholar who, in all his public life, sought earnestly and successfully the advancement of science. Our meeting here is a pilgrimage to his tomb.

In the early years, after the foundation of the government, a few great men were interested in the philosophy of science, in its facts and in research. Franklin was a physicist, Jefferson a naturalist, and Gallatin an anthropologist. These, and other great men of the time, drank deeply at the fountain of science; but they were statesmen, or they had other callings, and made the advancement of science a secondary purpose. But

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slowly scientific men rose, one after another, who devoted their entire energies to research. In the last generation, a galaxy of great scientific men appeared in the American firmament: Henry, Bache, Pierce, the Rogers brothers, Gray, Baird, and many others. These men devoted their lives to research and instruction in science. In 1840, they organized the Association of Geologists and Naturalists, and in 1848 they transformed that society into the American Association for the Advancement of Science. Since that time the society has embraced in its membership all, or nearly all, of the scientific men of America, and in the list of its officers—presidents, vice-presidents and secretaries—the names of many of the illustrious scientific men of the country are enrolled.

Most of the great men of that generation have sailed away on the unknown sea. A few only, like Dana, Hall, Newberry and Lesley, remain to guide in our councils and to cheer on the labors of the present generation of investigators. The society which they organized has grown with the growth of the country and the far more rapid growth of science, until it embraces a membership that constitutes a vast corps of laborers who occupy the border-land of knowledge which is the field of research. To enumerate in systematic order the fields of research occupied by the various members of this association would be to formulate a classification of the sciences.

Atoms, mountains and worlds, with all inorganic bodies and all inorganic motions, are to be examined in the study of the inorganic realm.

The phenomena of nature are qualitative and quantitative, and out of quantitative relation the abstract science of mathematics has been developed, and this science of measurement is rapidly being applied to the qualitative sciences. There are many men engaged in mathematical researches.

There are members who study the stars, compute their distances and determine their courses, and who are seeking to solve the mysteries of the constitution of the bright sun and the pale moon; for on the chariot of light they drive through the storms of the greater orb and explore the dim fields of the lesser.

Others with patient labor seek to discover the nature of light, of electricity and of gravity — the mysterious force that impels the universe.

There are others, many others, who are investigating the minute constitution of matter and determining its many forms. These forms are forever changing. The crystals of the rocks that make up the mountain mass are dissolved and their atoms redistributed in new forms, and chemical changes are in progress wherever human investigation can penetrate. The tree grows and decays, and man is but a form—a mold, through which streams of atoms pour in waves of chemic change. So the chemist studies the laws which govern the constitution of bodies and under which they are forever in flux.

There are others who are studying the molar motions and mechanical powers by which waters are made to turn mills, winds to waft vessels and steam to drag cars.

There are others who study the atmosphere which bathes the earth.

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They study the coming and going of storms, where fierce cycl
born, how the cold wave creeps from polar regions and the hot w
the tropics.

There are others who are studying the surface of the earth—
and seas in all their places and forms. At the far North there is
walled by ice a million and a half square miles in extent, but even
land of ice they penetrate. About the South pole there is an area
million square miles inclosed by a barrier of ice — an unknown r
to which the modern scholar is bound to enter. Between these
whole habitable earth is spread; and they are exploring all its se
gating all its rivers, climbing all its mountains and threading all it

A great army of men is engaged in the study of the constitutio
earth—the origin of mountains and valleys, of hills and prairie
canoes and geysers, of cataracts and caves and of rivers and l
seas. They examine the great coral reefs and islands of the sea,
study the great coral rocks of the land — the fossil reefs and i
ages gone by. Climbing among cliffs they study the anatomy of
canoes, and climbing to the brink of craters they study the physi
living volcanoes. If an earthquake rends the rocks, they measu
brations of its waves, and with the eye of science penetrate to t
of the disturbance and draw upon their maps the lines of weakn
crust of the earth. They follow the sands that are washed by sto
the mountain sides until they find them built by the sea into isl
coasts. With microscope and crucible they study the constitutio
ite, basalt, trachyte and other rocks wherein appear the crystal
many minerals. They show that the grand mountain form, with
and peaks and grottoes, where forests stand, where lakes are em
and where cataracts flash in the sunshine, is indeed an aggre
many gems beautiful in form and brilliant in color.

But man is not satisfied with the knowledge which comes with
of the inorganic realm; he essays to solve the mysteries of life.

An army of men is engaged in the investigation of vegetal lif
find minute but beautiful plants that grow as dust on polar ice
fields they find fungi, on rocks they find mosses, on the waves
sea-weeds, on tropical trees they find orchids, on the prairies the
ters, in the savannas they find lilies, in the jungle they find paln
forests they find oaks, on the mountain flanks they find sequoias;
study all these forms and a thousand more, and out of their stu
the science of botany. Then they must know how these forms
and they trace their origin in the dim past, and they exhume the
plant life from the tombs of ancient meadows and groves.

Then another army of men is engaged in the investigation
life, and they find the land and the sea teeming with varied form
sea the coral animals grow and build their weird structures. O
tom and shores of the sea mollusks crawl, carrying with them th
lined homes. There are mollusks in all the lakes, in all the riv
the brooks and in all the ponds, and they wander over the lands
the trees. On the lands there are crawling worms and in the se

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ing articulates, and the world is covered with crawling insects. The ants live in cities of their own building, the bees live on the clover blossoms and the butterflies play among the roses. The fishes swim in the waters, the reptiles crawl in the marshes, the birds fly in the air, and the beasts roam over the land. These animal forms are studied and classified, and we have systematic zoology. But this is not all of zoology. In the life of every living thing there is a wonderful history of transformation; so zoologists study the birth, growth and death of animals. Then they discover the origin of present tribes, by investigating the forms of life that have existed in the past, and they call upon the rocks to reveal their evolution.

Man essays to learn the marvellous structure of the human form, and the working of this complicated organism, and the processes by which the materials of the world are transformed into brawn and brain, and by which the powers of the dead universe are transformed into life. This study gives us the science of human biology. Having learned how men live, scholars seek to learn how men may live longer. In his course of conquest, man has transformed tribes of wild beasts into herds and flocks; he makes the cataract his slave and laughs at the lightning; a multitude of enemies by which he was once surrounded have now become his friends; in his puissance he seems to have conquered all; but while he has subdued many of his great enemies, he is surrounded by hosts of infinitesimal foes. He fears no attack of the lion, but he surrenders in death at the attack of the microbe, yet by light of science he seeks to disarm and destroy these infinitesimal foes.

Stars in their orbits, atoms in their affinities, plants in their growth, animals in their functions, present fields of research so vast, problems so recondite, that it might be supposed that the human reason would tremble under the load; but in fact the burthen thus carried has trained the powers of the mind to greater feats of reason, and man, triumphant in his researches through the universe of matter and life, essays at last to study himself, and he is organizing the science of anthropology. A galaxy of stars, a mountain of crystalline forms, a forest of plants, an island of life, are indeed subjects worthy of contemplation, but man, living in many lands, skilled in many arts, organized into many tribes and nations, speaking many languages, thinking many thoughts, propounding many philosophies, is the grander theme of anthropology.

At the threshold of anthropology we meet with the science which seeks to explain how life is transformed into mind; how the blush on the apple is transformed into the blush on the cheek, how the flight of the bird is transformed into the flight of the imagination, and how the brain with the nervous system is made the organ of this mind. How wonderful it is that sensation, perception, reasoning, memory, feeling, emotion and will appear as functions of this mysterious organ. In these researches many men are employed.

Man has sought out many inventions; thus we have the arts. To eat the berry from the bush, to munch the nut from the tree, to devour the clam on the bank, or to waylay a terrified hare, is to do no better than

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the brute; but to plant an orchard, to cultivate and stock a fishery, or to shepherd flocks, is to play the better part of man. To hide in caves is to compete with wolves; to construct homes is to become a creator. To seek protection from the pelting storm under the foliage is but a bird's device, but to clothe himself in raiment is the invention of man. So the arts of life are developed. First, man learned to use the mechanical powers; then he learned to utilize the subtle energies that pervade the universe. So all of the industrial arts have been invented. First he learned dancing, then rhythm, then melody, then harmony; until at last the fireside is cheered by song and the multitude filled with supreme emotion by choir and orchestra. At first he painted pictures on the skins of beasts and etched them on the rocks, and at last he paints pictures that mirror life and landscapes that mirror nature. At first he scratched signs on the bark of trees to mark the simple events of his journey; having invented letters and printing, he fills libraries with the records of his knowledge. So arts industrial and arts æsthetic were evolved, and the history of all these inventions has become the theme of modern investigation; and men excavate caves, open ancient graves, examine mounds and sift the debris of ruined cities for the materials of archæology.

There are many languages, and there are many men who study these languages, and they have created the science of philology. In the beginning man might shout his words across the creek, but to speak to his friend across the river he must swim the river; but now he speaks across the sea. There was a time when a spoken word died on the breeze, but now it is recorded for all time.

The evolution of animal life is by the method characterized as the survival of the fittest in the struggle for existence. It is a brutal method of progress. It is progress by pain and death. It means to starve the weak, to torture the unfortunate, and to rejoice in all calamity, for so progress is made in the animal world. The rule of nature, under the law of the survival of the fittest, involves the supremacy of claw and beak and poisoned fang. But man invents a new method of progress by human endeavor. He has organized institutions to establish peace, to secure justice and to promote mutual assistance. The organization of society and the establishment of laws to secure justice effect a repeal of the biotic law,—"the survival of the fittest in the struggle for existence." The rise and fall of states, the growth of forms of government, the development of law, and the interdependence of industries are subjects of inquiry with many men; and so researches relating to human institutions are organized, and a multitude of men are engaged in this work.

Man is an animal in body, stomach, and legs; but then he is an animal with opinions, and forever he has been systemizing these opinions into philosophies. In the earliest philosophy everything was endowed with life and deified—stones, trees, fountains, forests, beasts, winds, waves, and stars; and the mysteries of the universe were explained by making all these things intelligent actors. From this, the earliest philosophy of the lowest savage, it is a long way to the philosophy of science, and there have been many stages. That hollow dome, the firmament, has become infinite space;

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the wind, that was at first believed to be the breath of beasts stationed at the four corners of the earth, has at last become the circumambient air in motion under physical laws; the flat plain of earth has become a globe; astrology has become astronomy; alchemy has become chemistry; witchcraft has become medicine; beast gods have become domestic animals; and nature gods have become energies that can be used as the servants of man. The history of these opinions and of the philosophies into which they are woven is now a theme for the investigation of many men.

So the members of this society are prosecuting investigations in the realms of motion, life, and mind; and there is such a division of labor that every great science included in these realms has its devotees. It is a goodly work. It is a grand work.

Dr. JULIUS POHLMAN, of Buffalo, having been nominated by the COUNCIL, to fill the vacancy caused by the resignation of the General Secretary elected at the New York Meeting, was elected General Secretary for the Cleveland meeting.

The GENERAL SECRETARY announced that one hundred and twenty-six new members had been elected by the COUNCIL since the close of the New York Meeting, and that one hundred and thirty-seven papers had been presented for the present meeting.

On recommendation of the COUNCIL, it was voted that the forenoon sessions be held from 10 to 12½ o'clock, and that the afternoon sessions begin at 2 o'clock, standard time.

The PERMANENT SECRETARY stated that since the last meeting the Association had lost two of its original members: Prof. SPENCER F. BAIRD, who died August 19, 1887, was the first Permanent Secretary of the Association and held the office for the 5th, 6th and 7th meetings, the last being the meeting of 1853, held here in Cleveland.

Prof. ASA GRAY, the other original member, was President of the Indianapolis meeting in 1871. He died January 30, 1888.

Notices had also been received of the death of the following members.

HARDWAY H. DINWIDDIE, College Station, Tex. (32). Died Dec. 11, 1887.

GEORGE NEWELL DOGGETT, Chicago, Ill. (33). Died Jan. 15, 1887.

WALTER ANGUS DUN, Cincinnati, Ohio (31). Died Nov. 7, 1887.

EZEKIEL B. ELLIOTT, Washington, D. C. (10). The first Vice President of Section I. Died May 24, 1888.

JOSEPH FICKLIN, Columbia, Mo. (20). Died Sept. 6, 1887.

A. E. HEIGHWAY, Cincinnati, Ohio (29). Died Jan. 24, 1888.

HENRY A. HOMES, Albany, N. Y. (11). Died Nov. 3, 1887.

ROLAND DUER IRVING, Madison, Wis. (26). Died May, 1888.

ETHAN PENDLETON LARKIN, Alfred Center, N. Y. (33). Died Aug. 23, 1887.

HENRY CARVILL LEWIS, Philadelphia, Pa. (26) Died July 21, 1888.

MOSES LYFORD, Springfield, Mass. (22). Died Aug. 4, 1887.

A. R. MCCUTCHEN, Atlanta, Ga. (25). Died Nov. 21, 1887.

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DONALD MACGREGOR, Houston, Tex. (33). Died in October, 1887.
ELISHA N. SILL, Cuyahoga Falls, Ohio (6). Died April 26, 1888.
SILAS STEARNS, Pensacola, Fla. (28). Died Aug. 2, 1888.
JAMES STEVENSON, Washington, D. C. (29). Died July, 1888.
LEANDER STONE, Chicago, Ill. (32). Died April 2, 1888.
ALGERNON SIDNEY SULLIVAN, New York, N. Y. (36). Died Dec. 4, 1887.
ROBERT N. TAYLOR, Tollesboro, Lewis Co., Ky. (37). Died Aug. 13, 1888.
H. F. WALLING, Cambridge, Mass. (16). Died April 8, 1888.
SAMUEL D. WARREN, Boston, Mass. (29). Died May 11, 1888.
P. O. WILLIAMS, Watertown, N. Y. (24).
AMOS H. WORTHEN, Springfield, Ill. (5). Died May 6, 1888.

By direction of the COUNCIL the PERMANENT SECRETARY gave a statement of the financial condition of the Association. After announcements by the LOCAL SECRETARY, the GENERAL SESSION adjourned to meet in Sections.

In the evening, a GENERAL SESSION was held in the hall of the High School, at which a large number of citizens were present, and the Retiring President, Professor LANGLEY, delivered his address, entitled "The history of a scientific doctrine."

The GENERAL SESSION on Thursday was called to order by the PRESIDENT at 10 o'clock A. M.

Prof. C. J. H. WOODBURY of Boston, was elected Vice President of Section D to fill the vacancy caused by the absence of Prof. CALVIN M. WOODWARD. Notice was given that the WESTERN RESERVE HISTORICAL SOCIETY had invited the Association to visit its rooms between 1 and 6 o'clock P. M. on week days and from 3 to 6 o'clock on Sunday afternoon;— and that the CLEVELAND AUTOMATIC REFRIGERATOR Co. invited the Association to an inspection of its works on Friday, from 5 to 7 o'clock P. M.

At the GENERAL SESSION on Friday an invitation from Dr. CLARKE of Berea was received, for the inspection of his unique collection of fossil fishes. Several announcements were made regarding the Saturday's excursion.

In the evening Major POWELL delivered a lecture on "Competition as a factor in Human Progress."

At the GENERAL SESSION on Monday morning, Professor STALEY of the Case School of Applied Sciences, told why the Association had not been invited to visit the school, the cause being that only the bare walls of the new building were ready for inspection.

In the evening, Prof. T. C. MENDENHALL lectured on "Japanese magic mirrors."

The GENERAL SESSION was called to order on Tuesday morning by the Senior Vice President, Prof. GEORGE H. COOK. The names of the officers for the ensuing year, selected by the Nominating Committee, were presented as follows:

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PRESIDENT.

T. C. MENDENHALL of Terre Haute, Ind.

VICE PRESIDENTS.

A. Mathematics and Astronomy—R. S. WOODWARD of Washington.

B. Physics—H. S. CARHART of Ann Arbor, Mich.

C. Chemistry—WILLIAM L. DUDLEY of Nashville, Tenn.

D. Mechanical Science and Engineering—ARTHUR BEARDSLEY of Swarthmore, Pa.

E. Geology and Geography—CHARLES A. WHITE of Washington.

F. Biology—GEORGE L. GOODALE of Cambridge, Mass.

H. Anthropology—GARRICK MALLERY of Washington.

I. Economic Science and Statistics—CHARLES S. HILL of Washington.

PERMANENT SECRETARY.

F. W. PUTNAM of Cambridge, Mass. (office Salem, Mass.). Holds over.

GENERAL SECRETARY.

C. LEO MEES of Terre Haute, Ind.

SECRETARY OF THE COUNCIL.

FRANK BAKER of Washington.

SECRETARIES OF THE SECTIONS.

A. Mathematics and Astronomy—G. C. COMSTOCK of Madison, Wis.

B. Physics—E. L. NICHOLS of Ithaca, N. Y.

C. Chemistry—EDWARD HART of Easton, Pa.

D. Mechanical Science and Engineering—JAMES E. DENTON of Hoboken, N. J.

E. Geology and Geography—JOHN C. BRANNER of Little Rock, Ark.

F. Biology—AMOS W. BUTLER of Brookville, Ind.

H. Anthropology—W. M. BEAUCHAMP of Baldwinville, N. J.

I. Economic Science and Statistics—J. R. DODGE of Washington, D. C.

TREASURER.

WILLIAM LILLY of Mauch Chunk, Pa.

AUDITORS.

HENRY WHEATLAND of Salem, Mass., THOMAS MEEHAN of Germantown, Pa.

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On motion, it was voted that the SECRETARY be directed to cast a ballot for the election of the nominees, which was done and they were declared elected as officers for the next meeting.

On the recommendation of the Nominating Committee, it was voted to accept the invitation for Toronto and hold the next meeting there, beginning with the meeting of the COUNCIL on Tuesday, Aug. 27, 1889, and the first GENERAL SESSION on Wednesday, Aug. 28.

On recommendation of Section C, Dr. F. A. GENTH of Philadelphia, Pa., was elected an Honorary Fellow of the Association.

The SECRETARY announced that the following had been elected Fellows by the COUNCIL:—

Baylor, James B., U. S. Coast Survey, Washington, D. C. (35). **A**
Bigelow, F. H., Racine, Wis. (36). **A**
Boas, Franz, New York (36). **H**
Bransford, John Francis, Washington, D. C. (36). **H**
Campbell, Douglas H., Detroit, Mich. (34). **F**
Collingwood, Francis, Elizabeth, N. J. (36). **D**
Cushing, Henry Platt, Minn. Normal School, Mankato, Minn. (33). **E**
Denton, James E., Stevens Institute, Hoboken, N. J. (36). **D**
Green, Arthur L., Lafayette, Ind. (33). **C**
Howe, James Lewis, Louisville, Ky. (36). **C**
Johnson, Arnold Burges, Washington (35). **B**
Kemp, James F., Ithaca, N. Y. (36). **E**
Keiser, Edward H., Bryn Mawr, Pa. (35). **C**
Leavenworth, F. P., Haverford College, Pa. (30). **A**
Matthews, Washington, Washington, D. C. (37). **H**
McGill, John T., Vanderbilt University, Nashville, Tenn. (35). **C**
Menocal, A. G., Washington, D. C. (36). **D**
Nason, Frank L., Geological Survey of New Jersey, New Brunswick, N.J. (36). **E**
Nicholson, H. H., University of Nebraska, Lincoln, Neb. (36). **C**
Seymour, Wm. P., Troy, N. Y. (19). **H**
Sharpless, Isaac, President Haverford College, Pa. (33). **A**
Simonds, Frederick W., Fayetteville, Ark. (25). **E F**
Snyder, Henry, Oxford, Ohio (30). **B C**
Staley, Cady, Case School of Applied Science, Cleveland (37). **D**
Stevenson, J. J., University of City of New York (36). **E**
Thompson, Elihu, Lynn, Mass. (37). **B**
Tittman, O. H., Washington, D. C. (24). **A**
Towne, Henry R., Stamford, Conn. (33). **D E**
Tucker, Willis G., Albany, N. Y. (29). **C**
Ware, William R., Columbia College, New York (36). **D**
Warner, Worcester R., Cleveland, O. (33). **D**
Weber, Henry A., Ohio State University, Columbus, O. (35). **C**
Willson, R. W., Cambridge, Mass. (30). **A**
Wilson, Thomas, Washington, D. C. (36). **H**
Worthen, William E., New York (36). **D**

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The Committee on the Registration of Births, Marriages and Deaths, was discharged.

The Committee on Stellar Magnitudes was discharged at its own request.

The Committee on Anatomical Nomenclature, finding its work difficult, asked for an extension of time to prepare a report. Granted.

The Committee on Physics Teaching made a report and was continued.

The Committee on the Reduction of the Tariff on Scientific Books and Apparatus made a report and was continued.

The Committee on the Preservation of Archæologic Monuments on the Public Lands made a report and was continued.

The Committee on International Congress of Geologists reported through Prof. G. H. COOK.

Prof. C. H. HITCHCOCK moved that the report be accepted as presented and the committee be continued; seconded by Prof. N. H. WINCHELL and carried unanimously.

It was moved by Professor HARKNESS that all the reports be published in the Proceedings of the Association. Voted.

The Secretary announced that the COUNCIL recommended the formation of the following committees: and the same were duly elected.

On Chemistry Teaching. W. H. Seaman, William L. Dudley, H. W. Wiley, W. O. Atwater and W. A. Noyes.

On Water Analysis. G. C. Caldwell, J. W. Langley, J. A. Myers, W. P. Mason, R. B. Warder and W. H. Seaman.

On Organization of a National Chemical Organization. A. B. Prescott, Alfred Springer and Edward Hart.

Dr. A. B. Prescott was appointed substitute for Mr. Scudder on the committee on indexing chemical literature.

On a Universal Language. Horatio Hale, H. W. Henshaw, Alex. McFarland.

Mr. P. H. DUDLEY, the Honorary Special Agent of Transportation, made a report which was read and ordered to be printed in the Proceedings.

The concluding GENERAL SESSION was held on Tuesday evening August 21, in the hall of the High School. Vice President COOK presided in the enforced absence of President POWELL. The members of the Association were in good humor and were bound to show their appreciation of the hospitality and kindness of the Cleveland people which has been shown in so many ways during the meeting. Secretary POHLMAN announced that C. A. MARKS of Cleveland had been elected a member of the Association and then presented the following report from the Section on Anthropology, which was unanimously adopted:

Resolved, that we heartily commend the effort of the Western Reserve Historical Society to secure Fort Hill to the people of Ohio. That we appreciate highly the importance of preserving to all time in perfect condition one of the wonderful remains of antiquity, so fast disappearing, and

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recommend to the citizens of Ohio the work already begun at the Mound in that state by citizens of Massachusetts.

This resolution brought forth remarks on the necessity of pr the wonderful relics of prehistoric man which exist in Ohio an other parts of the country.

Professor PUTNAM said that it had been discovered that som works in Asia bear a strong resemblance to those in Ohio and it important to preserve the latter, in order that comparisons be the future. He called particular attention to the duty of the ci the state, upon whom largely rested the responsibility of rescui destruction these monuments of another race. He called upon th of Cleveland to furnish funds for that purpose. Fort Hill, he sa evidence of great antiquity, and it has a peculiar interest for all of archæology.

Mr. THOMAS WILSON of Washington, called attention to the me which European nations take care of their prehistoric monume emphasized the necessity for similar proceedings in the United

The following resolutions were then read:—

Resolved, that we, the members of the American Association Advancement of Science, hereby desire to express our heartfelt the LOCAL COMMITTEE selected by the citizens of Cleveland to l our well-being; that we duly appreciate the work done for our i comfort and pleasure and also that performed for the success of t ing by the subcommittees; that we gratefully record our oblig the genial secretary, Dr. ELROY M. AVERY, who with untiring has performed the laborious and often onerous duties of his i office.

Resolved, that the thanks of this Association are due and ar heartily tendered to the LADIES of the Local Committee and thei for their thoughtfulness, their devoted attention and their generou tality to members and their families during our stay in this beaut

We offer our thanks to the Managers of the Excursion to Kell and Put-in Bay, who had the rare foresight and wisdom to select occasion the most lovely day of the week, who provided for us and amiable company and who, without forgetting our materia delighted our ears with strains of sweet song and music rende corps of artists who gave evidence that Cleveland is a city where test survive' in many different forms. This favorable combinat the occasion one that will long linger in the memory of the fortun who participated. We particularly desire to place on record ou tions to Mr. and Mrs. S. T. Everett, Mr. and Mrs. Stewart Chish and Mrs. T. D. Crocker, Mr. and Mrs. R. K. Winslow, Mr. and Mrs H. Ely, Mr. and Mrs. W. S. Tyler, Mrs. J. E. Carey, and Mrs. J. F for the kindness shown us in opening their homes to us, giving

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portunity to see some of the most beautiful residences on one of the finest avenues in our country. Likewise to Mr. W. J. Gordon for opening his beautiful and extensive park for our enjoyment, and to Mr. and Mrs. L. E. Holden for the delightful reception given us at their charming summer residence on the lake shore.

The facilities of the High School, making it possible to hold the meetings of all the sections under one roof, are duly appreciated, and that this building was placed at the disposal of the Association for our meetings calls for a cordial expression of thanks to the Board of Education.

Our thanks are due to the Daily Press of Cleveland for the care which has been taken to publish abstracts of papers and addresses and long series of editorials and notices, by which the work of the Association has been placed before the public, again demonstrating its valuable aid in the diffusion of knowledge. To the Western Reserve Historical Society which opened its rooms at hours most convenient to the members of the Association, giving thereby an opportunity to examine the valuable collections accumulated by the energy and perseverance of a few far-sighted members of the community, we also offer our appreciative thanks.

To the Western Union Telegraph Company for placing its wires at the disposal of the members of the Association for the transmission of social messages; to the various Railroad Companies for granting reduced return fares; to the Telephone Exchange for facilities granted, and to a host of citizens of Cleveland who have contributed to the comfort and pleasure of the members of the Association during this our thirty seventh meeting, we offer our most grateful acknowledgment and our heartfelt thanks.

These resolutions were warmly seconded by Messrs. MASON, MUNROE, JASTROW, PEET, MENDENHALL, MORSE and BRINTON, and carried unanimously.

Professor HERBERT C. FOOTE of Cleveland, responded in behalf of the ladies of the Local Committee, and President CADY STALEY delivered a few timely remarks, wishing the visiting scientists godspeed and stating that, as he had predicted at the opening session, the people of Cleveland had been benefited by the meeting of the Association.

The PERMANENT SECRETARY then gave his usual statistical report of the meeting.

Vice President COOK then declared the meeting adjourned, and expressed the hope that all would meet again in Toronto in August, 1889.

JULIUS POHLMAN,
General Secretary.

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REPORT OF THE PERMANENT SECRETARY.

THE thirty-seventh meeting of the Association was guided b
generation than that of 1853, when its seventh meeting was held
land. Fortunately for the Association it yet has among its mos
members several who took part in the former meeting, and it is
the principles of its founders have been retained, so that the
changes, required to meet the demands made by the great advan
ence, have been brought about with due caution and have not t
Association away from the great object which led to its existen

As in the development of the Association itself, so in the city
land, thirty-five years have made great changes in national pr
development of resources, and in the wonderful application of
the arts for which the city is noted. This was well told at the m
Dr. Staley, the President of the Case School of Applied Science
which is destined to foster scientific research in its widest sense,
ing out the objects of its generous founder in properly applying s
the benefit of man. With all this great development in material
and in wealth, it is very apparent from the educational, historical
and artistic institutions of the city, that culture has not lagge
while the old-time generosity of the people was shown by the cor
ing and the kindly care given to the members of the Associat
meeting of 1888. That the next generation will find still further
with ample endowments for research in all departments of scien
foretold in a city where so much of its wealth has been secure
the application of scientific principles; but it is to be hoped
foundations will not be delayed too long, and that this beautiful c
lake will not be outstripped by her rivals in culture and progress

Several unfortunate circumstances resulted in a smaller atte
members at the meeting than was reasonably expected. The
date, made necessary by a great gathering in the city which too
the time first assigned for the meeting of the Association, and th
ing of the National Educational Association at a distant point, bo
to decrease the number of members in attendance at the Associat
natural aversion to going into the interior of the country in Augu
tells against such meetings, but, as numbers is not the primary ob
Association, a small meeting must not be looked upon as nece
unsuccessful one, and certainly this was not the case at Clevela

The three hundred and forty-two registered as members and
in attendance at the Cleveland meeting were from the following

City of Cleveland, not including the citizens who attended th
without joining the Association, 32; from the rest of Ohio, 43;
York, 56; Washington, 40; Massachusetts, 19; Pennsylvania, 18
16; Michigan, 16; Wisconsin, 12; Iowa, 11; Indiana, 11; Ne

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anada, 7; Connecticut, 6; Nebraska, 5; Kansas, 5; Kentucky, 4;
nia, 4; Mississippi, 4; Tennessee, 3; Minnesota, 3; Missouri, 3;
and, 3; Arkansas, 2; Texas, 2; Maine, 1; New Hampshire, 1; Rhode
l, 1; West Virginia, 1; North Carolina, 1; California, 1; Paris, 1.
he 182 members elected since the New York meeting, 130 have per-
their membership, also two who were elected at New York; and
y members have paid their arrears making 152 names added to the
nce the New York volume was published. From the New York list,
nes have been transferred to the list of Deceased Members, 20 Mem-
have resigned and 100 have been omitted for arrearages, making a
tion of 144 from the list. Five have become Life Members; 36 mem-
have been transferred to the list of Fellows, and one Fellow has been
an Honorary Fellow. Of the 1,964 now on the roll, 230 are at this
n arrears for the New York and Cleveland assessments.
following gives a comparative statement of the roll as printed in the
York volume and in the present volume.

	New York.	Cleveland.
Patrons	3	3
Members	1285	1271
Honorary Fellow	1	1
Fellows	667	689
Total	1956	1964

o hundred and fifteen papers were entered for the meeting, of which
re either declined or were not considered for lack of proper abstracts;
ere put on the daily programme for reading in the sections as fol-
— A 19, B 24, C 19, D 9, E 38, F 22, H 30, I 21. Of these 117 are
d in full or by abstract in the present volume, and 65 are mentioned
le. Of many of the latter, abstracts would have been printed had
r ones been prepared by the authors; others were to be printed in
other places. In addition to the papers, the addresses of the Pres-
and seven Vice Presidents, and the reports of eight committees were
, and are printed in the volume. Three evening lectures were also
ered. Several of the papers were illustrated by lantern projections
ulated by the late Dr. Howland, who, at considerable trouble and
se, took his unsurpassed outfit of lantern apparatus from Washing-
Cleveland.
e financial condition of the Association at the opening of the Cleve-
neeting is shown by the annexed cash account, covering the year
August 1, 1887 to August 1, 1888, and including the New York meet-
From this account it will be seen that the last year was an excep-
lly prosperous one financially, the receipts from regular sources,
ding admission fees, assessments and sales, amounting to $7,119.62;
the regular expenses of the year, including the publication and dis-
tion of the New York volume, office expenses and salaries, were
2.14. In addition to the above receipts were the $1,723 in gifts which

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more than paid the $1,602.73 expended for reprinting back volumes of the Proceedings so that full sets can now be furnished. Of the $2,751.45 due the Permanent Secretary for balances on salary for several years back, all but $463.70 was paid, which is the only debt of the Association.

$1,050 was obtained from life membership commutations and carried to the Research Fund. It will also be noticed that $300 income from this fund was granted for the encouragement of research at the New York meeting.

THE RESEARCH FUND amounted on Aug. 1, 1888, principal and interest to $4,414.27

THE GENERAL FUND, Aug. 1, 1888, principal and interest, ... $112.05

By vote of the Council, $200 was granted to aid in the archæological explorations at the Serpent Mound, by the Curator of the Peabody Museum.

Leaving total of invested funds $4,326.32

The proposed formation of an American Geological Society and of an American Chemical Society has led to considerable discussion as to the good or bad effects of such organizations upon the respective sections in the Association of which they are the offspring. The discussion has also embraced the Entomological and Botanical Clubs of the Association, and the Society for the Promotion of Agricultural Science, which hold their meetings in connection with those of the Association.

Various opinions have been expressed which I do not propose to discuss, but there are some considerations worthy of the attention of all members of the Association.

In regard to the Society for the Promotion of Agricultural Science, it can be said without qualification that it has been of benefit to the Association. This Society has its annual meeting on the Tuesday preceding the first General Session of the Association, and, I believe, also one or two special meetings during the week, but always at times not conflicting with the sections with which the Society is affiliated. The result has been that most of the agricultural chemists of the country and many other men particularly interested in agricultural science have joined the Association and taken an active part in its meetings, while they would be drawn from it should their special society meet at some other time and place, and its members fully realize the importance of the benefits they receive as members of the Association, and the great opportunity they have of annually meeting so many workers in other but kindred branches of science.

The same is largely the case with the Entomological and Botanical Clubs, although in these clubs the members are primarily members of the Association and in regular attendance at the meeting. It can only be said against these clubs that many papers are presented and discussed in the clubs which would add largely to the interest of Section F; but it must also be acknowledged that the members of the clubs have been of late years among the principal supporters of the Section, and that the Section has certainly profited by the social elements of the clubs.

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The result of the formation of the Geological and Chemical Societies can not yet be foretold, as that will depend upon the plan to be adopted for their meetings. Should these societies wisely arrange to hold their meetings so as not to conflict with the two sections which they represent, by holding their annual meeting on the Tuesday before the first General Session of the Association and their special meetings by agreement with the respective section to suspend its meeting for a half day or a day as might be arranged, and the rest of the time meet with the sections, it seems as if only good could result; particularly if all the members of the societies were also members of the Association, and this would follow naturally under such an arrangement.

Certainly in such a body as the Association, composed of workers in, and supporters and lovers of all departments of science, there is strength in union; and while any small portion might flourish for a time as an organization of specialists, entirely independent of the larger body of workers and supporters, it would be very short-sighted policy for any such body to cut the strings by which their own special work is bound to the still larger and grander work of the general advancement of human knowledge. With the mutual benefits to be derived from a close union of all special scientific societies — each necessarily narrowed by its specialty — with the great popular and spreading influence of the Association, where all united make a grand whole worthy the support of every one, it can hardly be questioned but that the mother of all will be faithfully sustained in the councils of her wise children.

F. W. PUTNAM,
Permanent Secretary.

Salem, Masse, May 9, 1889.

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F. W. PUTNAM, PERMANENT SECRETARY

Dr. THE AMERICAN ASSOCIATION FO
1887–8.

To admission fees New York Meeting	$1,325 00	
" " previous to New York Meeting	10 00	
Fellowship fees	110 00	
		$1,445
Assessments previous to New York . . .	819 00	
" for New York Meeting . . .	3,705 00	
" " Cleveland Meeting . . .	726 00	
" Associates, New York . . .	276 00	
		5,526
Publications sold	78 53	
Received for binding	63 14	
Postage and express refunded	3 13	
Incidental receipts	3 82	
		148
Gift of Mr. William Thaw of Pittsburg, Pa.	100 00	
" " " C. G. Hussey " " "	100 00	
" " " Geo. Westinghouse, jr. of Pittsburg, Pa.	50 00	
" " " Henry Phipps of Pittsburg, Pa.	50 00	
" " Ladies Committee, N. Y. Meeting .	303 00	
		603
Life membership commutations		1,050
Income Research fund		300
Reprint fund:—		
Mrs. Thompson's gift . . .	1,000 00	
3 years interest	120 00	
		1,120 0
Balance due Permanent Secretary, to next acct.		463 7

$10,656 32

I have examined the above account and it

SALEM, MASS., AUGUST 7, 1888.

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NCEMENT OF SCIENCE. Cr.

1887–8.

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ly cast and properly vouched.

HENRY WHEATLAND, *Auditor.*

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ERRATA.

The paper by Mr. Horton on page 375 was printed before return of proof from a
Hence several minor errors have passed uncorrected. The only important erro
ticed by the author are the omission of an "s" after "economist," page 378, line 1
the word "in" for "is" in line 25 of the same page. "Trade is Barter."

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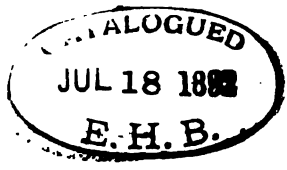

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e 250, in title of paper, for " Makoqueta " read Maquoketa.

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W. H. Beatly, Dr. Bryce, B. Cumberland, Professor Baker, A. M. Cosby, Dr. Davison. Prof. Ellis, Ald. Gibbs, Dr. Hodgins, John Hoskin, Professor Loudon, Principal Kirkland, William Macdonald, W. B. McMurrich, Dr. O'Sullivan, Ald. McMillan, J. H. Pearce, Rev. J. R. Teefy, Prof. A. H. Wright, Prof. R. R. Wright, Dr. J. E. White, W. H. VanderSmissen.

COMMITTEE ON HOTELS.

Chairman, THOMAS MCGAW, *Secretary*, W. MCCULLOCH.

D. Boyle, H. J. Hill, John Hallam, Robert Jaffray, Bernard Saunders, David Walker J. Wright.

POST-OFFICE, TELEGRAPH AND EXPRESS COMMITTEES.

Chairman, H. P. DWIGHT, *Secretary*, G. SWEETNAM, JR.

Arthur Cox, D. B. Dick, A. Blue, O. S. Howland, R. E. Kingsford, H. Neilson, Dr. Roseburgh, Professor Shuttleworth, J. D. Irwin.

TRANSPORTATION COMMITTEE.

Chairman, E. WRAGGE, *Secretary*, W. R. CALLAWAY.

Hugh Blain, B. Cumberland, P. H. Drayton, A. T. Hill, H. S. Howland, N. Kingsmill, F. Nichols, H. Merritt, William Badenach, P. J. Slatter.

FINANCE COMMITTEE.

Chairman, D. R. WILKIE, *Secretary*, JAMES BAIN.

Professor Baker, W. Barwick, W. R. Brock, R. Burgess, R. W. Elliott, R. Jenkins, W. S. Lee, J. H. Mason, G. R. R. Cockburn, William Badenach, J. H. Pearce.

COMMITTEE ON ROOMS.

Chairman, A. MARLING, *Secretary*, A. F. CHAMBERLAIN.

G. Dickson, F. Darling, J. L. Huges, D. R. Keys, John Squair.

PRINTING COMMITTEE.

Chairman, ALAN MACDOUGALL, *Secretary*, G. ADAMSON.

Professor Ashley, D. Boyle, J. M. Clark, W. Houston, Dr. Pyne, G. M. Rae, G. Kennedy.

PRESS COMMITTEE.

Chairman, JAMES HEDLEY, *Secretary*, R. T. LANCEFIELD.

T. B. Browning, C. R. W. Biggar, H. Brock, D. Creighton, John Cameron, E. Farrar, W. F. Maclean, J. R. Robertson, A. S. Irving, W. G. Eakins, C. W. Taylor, Rev. Dr. Dewart.

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SPECIAL COMMITTEES OF THE ASSOCIATION.[1]

1. *Committee on Indexing Chemical Literature.*

H. CARRINGTON BOLTON of New York,
F. W. CLARKE of Washington,
A. R. LEEDS of Hoboken,
A. A. JULIEN of New York,
J. W. LANGLEY of Ann Arbor,
C. K. WEAD of Malone.

A. B. PRESCOTT of Ann Arbor.

2. *Committee on International Congress of Geologists.*

JAMES HALL of Albany,
J. S. NEWBERRY of New York,
T. STERRY HUNT of Montreal,
C. H. HITCHCOCK of Hanover,
RAPHAEL PUMPELLY of Newport,
J. P. LESLEY of Philadelphia,
JOHN J. STEVENSON of New York,
E. D. COPE of Philadelphia,
E. A. SMITH of Tuscaloosa,
H. S. WILLIAMS of Ithaca,
N. H. WINCHELL of Minneapolis,
JAMES D. DANA of New Haven,
WILLIAM B. SCOTT of Princeton,
ROBERT BELL of Ottawa,

PERSIFOR FRAZER of Philadelphia.

3. *Committee on Anatomical Nomenclature, with Special reference to the Brain.*

HARRISON ALLEN of Philadelphia,
HENRY F. OSBORN of Princeton,
T. B. STOWELL of Cortland,
B. G. WILDER of Ithaca,

FRANK BAKER of Washington.

4. *Committee to apply to Congress for a Reduction of the Tariff on Scientific Books and Apparatus.*

E. D. COPE of Philadelphia,
J. R. EASTMAN of Washington,

JOHN S. BILLINGS of Washington.

5. *Committee to memorialize Congress to take steps for the Preservation of Archæologic Monuments on the public lands.*

MISS ALICE C. FLETCHER of Cambridge,
MRS. T. E. STEVENSON of Washington.

[1] All Committees are expected to present their reports to the COUNCIL not later than the fourth day of the meeting. Committees sending their reports to the Permanent Secretary one month before a meeting can have them printed for use at the meeting.

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6. *Committee on Universal Language.*

HORATIO HALE of Clinton, | H. W. HENSHAW of Washington,
ALEX. MACFARLANE of Austin.

7. *Committee on Water Analysis.*

G. C. CALDWELL of Ithaca, | J. W. LANGLEY of Ann Arbor,
J. A. MYERS of Agricultural Coll., Miss., | W. P. MASON of Troy,
R. B. WARDER of Washington, | W. H. SEAMAN of Washington.

8. *Committee to Report to Council upon a Memorial in relation to Universal Day.*

R. S. WOODWARD of Washington, | CHARLES CARPMAEL of Toronto,
W. A. ROGERS of Waterville, | W. H. DALL of Washington.

9. *Committee on the Maintenance of Timberlands and on the Develop of the Natural Resources of the Country.*

T. C. MENDENHALL of Washington, | C. E. BESSEY of Lincoln,
E. W. HILGARD of Berkley, | B. E. FERNOW of Washington.
WILLIAM SAUNDERS of Ottawa.

10. *Committee on Spelling and Pronouncing Chemical Terms.*

THOMAS H. NORTON of Cincinnati, | JAMES LEWIS HOWE of Louisville,
H. CARRINGTON BOLTON of New York, | EDWARD HART of Easton.

11. *Honorary Agent of Transportation for the Association to act with Local Committees.*

P. H. DUDLEY of New York.

12. *Auditors.*

HENRY WHEATLAND of Salem, | THOMAS MEEHAN of Germantown.

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OFFICERS ELECTED

FOR THE

INDIANAPOLIS MEETING.

PRESIDENT.

GEORGE L. GOODALE of Cambridge, Mass.

VICE PRESIDENTS.

Mathematics and Astronomy—S. C. CHANDLER of Cambridge, Mass.

Physics—CLEVELAND ABBE of Washington.

Chemistry—R. B. WARDER of Washington.

Mechanical Science and Engineering—JAMES E. DENTON of Hoboken, N. J.

Geology and Geography—JOHN C. BRANNER of Little Rock, Ark.

Biology—C. S. MINOT of Boston, Mass.

Anthropology—FRANK BAKER of Washington.

Economic Science and Statistics—J. RICHARDS DODGE of Washington.

PERMANENT SECRETARY.

. PUTNAM of Cambridge (office Salem, Mass.), reëlectd for five years.

GENERAL SECRETARY.

H. CARRINGTON BOLTON of New York.

SECRETARY OF THE COUNCIL.

JAMES LOUDON of Toronto.

SECRETARIES OF THE SECTIONS.

Mathematics and Astronomy—WOOSTER W. BEMAN, of Ann Arbor, Mich.

Physics—W. LECONTE STEVENS of Brooklyn, N. Y.

Chemistry—W. A. NOYES of Terre Haute, Ind.

Mechanical Science and Engineering—M. E. COOLEY of Ann Arbor, Mich.

Geology and Geography—SAMUEL CALVIN of Iowa City, Iowa.

Biology—JOHN M. COULTER of Crawfordsville, Ind.

Anthropology—JOSEPH JASTROW of Madison, Wis.

Economic Science and Statistics—S. DANA HORTON of Pomeroy, Ohio.

TREASURER

WILLIAM LILLY of Mauch Chunk, Pa.

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MEETINGS AND OFFICERS OF THE AMERICAN ASSOCIATION OF GEOLOGISTS AND NATURALISTS.

MEETING.	DATE.	PLACE.	CHAIRMAN.	SECRETARY.	ASSIS'T SEC'Y.	TREASURER.
1st	April 2, 1840,	Philadelphia,	Edward Hitchcock,*	L. C. Beck,*		
2d	April 5, 1841,	Philadelphia,	Benjamin Silliman,*	L. C. Beck,*	B. Silliman, jr.,* C. B. Trego,*	
3d	April 25, 1842,	Boston,	S. G. Morton,*	C. T. Jackson,*	J. D. Whitney, M. B. Williams,*	
4th	April 26, 1843,	Albany,	Henry D. Rogers,*	B. Silliman, jr.,*		John Locke.*
5th	May 8, 1844,	Washington,	John Locke,*	B. Silliman, jr.,* O. P. Hubbard,		Douglas Houghton.*
6th	April 30, 1845,	New Haven,	Wm. B. Rogers,*	B. Silliman, jr.,* J. Lawrence Smith,*		Douglas Houghton.*
7th	Sept. 2, 1846,	New York,	C. T. Jackson,*	B. Silliman, jr.,*		E. C. Herrick.*
8th	Sept. 20, 1847,	Boston,	Wm. B. Rogers,†*	Jeffries Wyman,*		B. Silliman, jr.*

* Deceased.

† Professor ROGERS, as chairman of this last meeting, called the first meeting of the new Association to order and presided until it was fully organized by the adoption of a constitution. As he was thus the first presiding officer of the new Association, it was directed at the Hartford meeting that his name be placed at the head of the Past Presidents of the American Association for the Advancement of Science.

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1st	Sept. 20, 1848,	Philadelphia, Pa.,	W. C. Redfield,*		Walter R. Johnson,*		Jeffries Wyman.*
2d	Aug. 14, 1849,	Cambridge, Mass.,	Joseph Henry,*		E. N. Horsford, 1		A. L. Elwyn.*
3d	Mar. 12, 1850,	Charleston, S. C.,	A. D. Bache,* 2		L. R. Gibbs, 3		St. J. Ravenel.* 4
4th	Aug. 19, 1850,	New Haven, Conn.,	A. D. Bache,*		E. C. Herrick,*		A. L. Elwyn.*
5th	May 5, 1851,	Cincinnati, Ohio,	A. D. Bache,*		W. B. Rogers, 5*	S. F. Baird,*	S. F. Baird. 6
6th	Aug. 19, 1851,	Albany, N. Y.,	Louis Agassiz,*		W. B. Rogers,*	S. F. Baird,*	A. L. Elwyn.*
7th	July 28, 1853,	Cleveland, Ohio,	Benjamin Pierce,*		S. St. John,* 7	S. F. Baird,*	A. L. Elwyn.*
8th	April 26, 1854,	Washington, D. C.,	J. D. Dana.		J. Lawrence Smith,*	Joseph Lovering,	J. L. LeConte* 8
9th	Aug. 15, 1855,	Providence, R. I.,	John Torrey,*		Wolcott Gibbs,	Joseph Lovering,	A. L. Elwyn.*
10th	Aug. 20. 1856,	Albany, N. Y.,	James Hall,		B. A. Gould,	Joseph Lovering,	A. L. Elwyn.*
11th	Aug. 12, 1857,	Montreal, Canada,	Alexis Caswell,* 9	Alexis Caswell.*	John LeConte,	Joseph Lovering,	A. L. Elwyn.*
12th	April 28, 1858,	Baltimore, Md.,	Alexis Caswell,* 10	John E. Holbrook,*†	W. M. Gillespie,* 11	Joseph Lovering,	A. L. Elwyn.*
13th	Aug. 3, 1859,	Springfield, Mass.,	Stephen Alexander,*	Edward Hitchcock,*	William Chauvenet,*	Joseph Lovering,	A. L. Elwyn.*
14th	Aug. 1, 1860,	Newport, R. I.,	Isaac Lea.*	B. A. Gould,	Joseph LeConte,	Joseph Lovering,	A. L. Elwyn.*
15th	Aug. 15, 1866,	Buffalo, N. Y.,	F. A. P. Barnard,*	A. A. Gould,* 12	Elias Loomis, 13	Joseph Lovering,	A. L. Elwyn.†*
16th	Aug. 21, 1867,	Burlington, Vt.,	J. S. Newberry,	Wolcott Gibbs,	C. S. Lyman,	Joseph Lovering,	A. L. Elwyn.†*
17th	Aug. 5, 1868,	Chicago, Ill.,	B. A. Gould,	Charles Whittlesey,*	Simon Newcomb. 14	Joseph Lovering,	A. L. Elwyn.†*
18th	Aug. 18, 1869,	Salem, Mass.,	J. W. Foster.*	O. N. Rood,	O. C. Marsh,	F. W. Putnam, 15	A. L. Elwyn.†*
19th	Aug. 17, 1870,	Troy, N. Y.,	T. S. Hunt, 16	T. S. Hunt,	F. W. Putnam, 17	Joseph Lovering,	A. L. Elwyn.†*
20th	Aug. 16, 1871,	Indianapolis, Ind.,	Asa Gray,*	G. F. Barker,	F. W. Putnam,	Joseph Lovering,	W. S. Vaux.*
21st	Aug. 15, 1872,	Dubuque, Iowa,	J. Lawrence Smith,*	Alex. Winchell,	E. S. Morse,	Joseph Lovering,	W. S. Vaux.*
22d	Aug. 20, 1873,	Portland, Me.,	Joseph Lovering,	A. H. Worthen,†*	C. A. White,	F. W. Putnam,	W. S. Vaux.*
23d	Aug. 12, 1874,	Hartford, Conn.,	J. L. LeConte,*	C. S. Lyman,*	A. C. Hamlin,	F. W. Putnam,	W. S. Vaux.†*

1. In place of Jeffries Wyman, *not present.*
2. In place of Joseph Henry, *not present.*
3. In place of E. C. Herrick, *not present.*
4. In place of A. L. Elwyn, *not present.*
5. In place of E. C. Herrick, *not present.*
6. In place of A. L. Elwyn, *not present.*
7. In place of J. D. Dana, *not present.*
8. In place of A. L. Elwyn, *not present.*
9. In place of J. W. Bailey, *deceased.*
10. In place of Jeffries Wyman, *not present.*
11. In place of Wm. Chauvenet, *not present.*
12. In place of R. W. Gibbes, *not present.*
13. In place of W. P. Trowbridge, *not present.*
14. In place of A. P. Rockwell, *called home 1st day.*
15. In place of Joseph Lovering, *in Europe.*
16. In place of Wm. Chauvenet, *too ill to be present.*
17. In place of C. F. Hartt, *in Brazil.*

* Deceased. † Not present at the meeting.

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MEETINGS AND OFFICERS OF THE ASSOCIATION (*Continued*).

MEET-ING.	DATE.	PLACE.	PRESIDENT.	VICE PRESIDENT, SECTION A.	VICE PRESIDENT, SECTION B.	CHAIRMAN OF PERMANENT SUBSECTION OF CHEMISTRY.	CHAIRMAN OF PERMANENT SUBSECTION OF ANTHROPOLOGY.	CHAIRMAN OF PERMANENT SUBSECTION OF MICROSCOPY.	CHAIRMAN OF PERMANENT SUBSECTION OF ENTOMOLOGY.
24th	Aug. 11, 1875.	Detroit, Mich.,	J. E. Hilgard,	H. A. Newton,	J. W. Dawson,	S. W. Johnson,	L. H. Morgan,*	———	———
25th	Aug. 23, 1876.	Buffalo, N. Y.,	W. B. Rogers,*	C. A. Young,	E. S. Morse,	G. F. Barker,	L. H. Morgan,*	R. H. Ward,	———
26th	Aug. 29,,1877.	Nashville, Tenn.,	S. Newcomb,	R. H. Thurston,[1]	O. C. Marsh,	N. T. Lupton,	Daniel Wilson,†	R. H. Ward,	———
27th	Aug. 21, 1878.	St. Louis, Mo.,	O. C. Marsh,	R. H. Thurston,	Aug. R. Grote,	F. W. Clarke,	———[2]	R. H. Ward,[3]	———
28th	Aug. 27, 1879.	Saratoga, N. Y.,	G. F. Barker,	S. P. Langley,	J. W. Powell,	F. W. Clarke,[4]	Daniel Wilson,	E. W. Morley,	———
29th	Aug. 25, 1880.	Boston, Mass.,	L. H. Morgan,*	Asaph Hall,	Alex. Agassiz,	J. M. Ordway,	J. W. Powell,	S. A. Lattimore,	———
30th	Aug. 17, 1881.	Cincinnati, Ohio,	G. J. Brush,	Wm. Harkness,[7]	E. T. Cox,[8]	G. C. Caldwell,[9]	G. Mallery,	A. B. Hervey,	J. G. Morris.

PERMANENT SECRETARY.	GENERAL SECRETARY.	SECRETARY OF SECTION A.	SECRETARY OF SECTION B.	SECRETARY OF PERMANENT SUBSECTION OF CHEMISTRY.	SECRETARY OF PERMANENT SUBSECTION OF ANTHROPOLOGY.	SECRETARY OF PERMANENT SUBSECTION OF MICROSCOPY.	SECRETARY OF PERMANENT SUBSECTION OF ENTOMOLOGY.	TREASURER.
F. W. Putnam,	S. H. Scudder,	S. P. Langley, T. C. Mendenhall,	E. S. Morse,	F. W. Clarke,	F. W. Putnam,	———	———	W. S. Vaux.*
F. W. Putnam,	T. C. Mendenhall,	A. W. Wright,	Albert H. Tuttle,	H. C. Bolton,	O. T. Mason,	E. W. Morley,	———	W. S. Vaux.*
F. W. Putnam,	Aug. R. Grote,	H. C. Bolton,	Wm. H. Dall,	P. Schweitzer,	———[2]	T. O. Summers, jr.,	———	W. S. Vaux.†*
F. W. Putnam,	H. C. Bolton,	F. E. Nipher,	George Little,	A. P. S. Stuart,	———[2]	G. J. Engelmann,	———	W. S. Vaux.†*
F. W. Putnam,	H. C. Bolton,[5]	J. K. Rees,	W. H. Dall,[6]	W. R. Nichols,*	J. G. Henderson,	A. B. Hervey,	———	W. S. Vaux.†*
F. W. Putnam,	J. K. Rees,	H. B. Mason,	C. V. Riley,	C. E. Munroe,	J. G. Henderson,	A. B. Hervey,	———	W. S. Vaux.*
F. W. Putnam,	C. V. Riley,	E. T. Tappan,[10]	Wm. Saunders,	A. Springer,[12]	J. G. Henderson,	W. H. Seaman,[11]	B. P. Mann,	W. S. Vaux.†*

[1] In the absence of E. C. Pickering.
[2] The Subsection united with Sec. B.
[3] In the absence of G. S. Blackie.
[4] In the absence of George Little.
[5] In the absence of Ira Remsen.
[6] In the absence of A. C. Wetherby.
[7] In the absence of A. M. Mayer.
[8] In the absence of George Engelmann.
[9] In the absence of W. R. Nichols.
[10] In the absence of John Trowbridge.
[11] In the absence of S. P. Sharples.
[12] In place of H. W. Wiley, called away.

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MEETING.	DATE.	PLACE.	PRESIDENT.	VICE PRESIDENTS.				
				Section A.	Section B.	Section C.	Section D.	Section E.
31st	Aug. 23, 1882.	Montreal, Can.	J. W. Dawson,	W. A. Rogers,[1]	T.C. Mendenhall,	H. C. Bolton,	W. P. Trowbridge,	E. T. Cox,
32nd	Aug. 15, 1883.	Minneapolis, M.	C. A. Young,	W. A. Rogers,	H. A. Rowland,	E. W. Morley,	De Volson Wood,[7]	C.H. Hitchcock,
33rd	Sept. 3, 1884.	Philadelphia, Pa.	J. P. Lesley,	H. T. Eddy,	J. Trowbridge,	J. W. Langley,	R. H. Thurston,	N. H. Winchell,
34th	Aug. 26, 1885.	Ann Arbor, Mich.	H. A. Newton,	W. Harkness,[15]	S. P. Langley,[16]	N. T. Lupton,[17]	J. Burkitt Webb,	Edward Orton,
35th	Aug. 18, 1886.	Buffalo, N. Y.	E. S. Morse,	J. W. Gibbs,	C. F. Brackett,	H. W. Wiley,	O Chanute,	T. C Chamberlin,
36th	Aug. 10, 1887.	New York, N. Y.	S. P. Langley,	J .R. Eastman,[24]	W. A. Anthony,	A. B. Prescott	E. B. Coxe,	G. K. Gilbert,

VICE PRESIDENTS.				Permanent Secretary.	General Secretary.	Assistant Gen. Secretary.	SECRETARIES OF SECTIONS.	
Section F.	Section G.	Section H.	Section I.				Section A.	Section B.
W. H. Dall,	A. H. Tuttle,	Alex. Winchell,[2]	E. B. Elliott,	F. W. Putnam,	Wm. Saunders,	J. R. Eastman.	H. T. Eddy,	C. S. Hastings,
W. J. Beal,	J. D. Cox.	O. T. Mason,	F. B. Hough,[3]	F. W. Putnam,	J. R. Eastman.	Alfred Springer,	G. W. Hough,[8]	F. E. Nipher.[9]
E. D. Cope.	T. G.Wormley,	E. S. Morse,	John Eaton,	F. W. Putnam.	Alfred Springer,	C. S. Minot.[19]	G. W. Hough,	N. D. C. Hodges,
T. J. Burrill,[18]	S. H. Gage,	J. O. Dorsey,[19]	Edw. Atkinson	F. W. Putnam,	C. S. Minot,	S. G. Williams.[20]	E. W. Hyde.	B. F. Thomas,[21]
H. P.Bowditch,	———[25]	H. Hale,	Jos. Cummings	F. W. Putnam.	S. G. Williams,	W. H. Pettee,	S. C. Chandler,	H. S. Carhart.
W. G. Farlow,	———	D. G. Brinton,	H. E. Alvord,	F. W. Putnam.	W. H. Pettee,	J. C. Arthur,	H. M. Paul,	C. Leo Mees,

SECRETARIES OF THE SECTIONS.							Treasurer.
Section C.	Section D	Section E.	Section F.	Section G.	Section H.	Section I.	
Alfred Springer,	J. B. Webb,[3]	H. S. Williams,[4]	Wm. Osler,[5]	Robt. Brown, jr.,	O. T. Mason,	F. B. Hough.[6a]	———*[6]
J. W. Langley,[10]	J. B. Webb,[11]	A. A. Julien,	S. A. Forbes,	Carl Seiler,	G. H. Perkins,	Jos. Cummings,	William Lilly.
H. Carmichael,[13]	J. B. Webb,	E. A. Smith.	C. E. Bessey,	R. Hitchcock,	G. H. Perkins.[14]	C. W. Smiley,	William Lilly.
F.P.Dunnington.	C. J. H. Woodbury,	G. K. Gilbert,[22]	J. A. Lintner,[23]	W. H. Walmsley,	Erm. A. Smith,*	C. W. Smiley,[24]	William Lilly.
W. McMurtrie,	William Kent,	E. W. Claypole,	J. C. Arthur,	———[26]	A. W. Butler,	H. E. Alvord,	William Lilly.
C. S. Mabery,[27]	G. M. Bond,	W. M. Davis,[28]	J. H. Comstock,	———	C. C. Abbott,[29]	W. R. Lazenby,	William Lilly.

1 In the absence of William Harkness.
2 In the absence of Daniel Wilson.
3 In the absence of C. B. Dudley.
4 In the absence of C. E. Dutton.
5 In the absence of C. S. Minot.
6 F. B. Hough was called home and J. R. Dodge acted at the close of the meeting.
7 Absent but place was not filled
8 In the absence of W. W. Johnson.
9 In the absence of C. K. Wead.
10 W. M. McMurtrie, last three days of meeting.
11 Pro tempore.
12 In the absence of R. S. Holden.
13 In the absence of R. B. Warder.
14 In the absence of W. H. Holmes.
15 In the absence of J. M. Van Vleck.
16 In place of C. F. Brackett, resigned.
17 In the absence of W. R. Nichols.
18 In the absence of B. G. Wilder.
19 In the absence of W. H. Dall.
20 In place of C. C. Abbott, not present
21 In place of A.A. Michelson, resigned.
22 In the absence of H. C. Lewis.
23 In place of C. H. Fernald, resigned.
24 In the absence of J. W. Chickering.
25 Section permanently united to Section F.
26 In place of W. Ferrel, resigned.
27 Absent; R. B. Warder acted as Sec'y pro tem.
28 In place of T. R. Comstock, absent.
29 In place of F. W. Langdon, absent.
*Deceased.

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MEETINGS AND OFFICERS OF THE ASSOCIATION (C

MEETING.	DATE.	PLACE.	PRESID
37th.	Aug. 15, 1888.	Cleveland, Ohio.	J. W. Powell.
38th.	Aug. 27, 1889.	Toronto, Ontario.	T. C. Mendenh

VICE PRESIDENTS.

SECTION A.	SECTION B.	SECTION C.	SECT
Ormond Stone.	A. A. Michelson.	C. E. Munroe.	C. J. H.
R. S. Woodward.	H. S. Carhart.	W. L. Dudley.	James E.

SECTION E.	SECTION F.	SECTION H.	SECT
George H. Cook.	C. V. Riley.	C. C. Abbott.	C. W. Sm
Charles A. White.	Geo. L. Goodale.	Garrick Mallery.	Charles S

PERMANENT SECRETARY.	GENERAL SECRETARY.	SECRETARY OF COUNCIL.	TREA
F. W. Putnam.	Julius Pohlman.	C. Leo Mees.	William I
F. W. Putnam.	C. Leo Mees.	H. C. Bolton.	William I

SECRETARIES OF SECTIONS.

SECTION A.	SECTION B.	SECTION C.	SECT
C. C. Doolittle.	A. Macfarlane.	W. L. Dudley.	Arthur B
G. C. Comstock.	E. L. Nichols.	Edward Hart.	W. B. W

SECTION E.	SECTION F.	SECTION H.	SEC
John C. Branner.	B. H. Fernow.	Frank Baker.	Charles S
John C. Branner.	A. W. Butler.	W. M. Beauchamp.	J. R. Doo

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ETINGS.	PLACE.	YEAR.	MEMBERS IN ATTENDANCE.	NUMBER OF MEMBERS.
1.	Philadelphia	1848	?	461
2.	Cambridge	1849	?	540
3.	Charleston	1850	?	622
4.	New Haven	1850	?	704
5.	Cincinnati	1851	87	800
6.	Albany	1851	194	769
7.	Cleveland	1853	?	940
8.	Washington	1854	168	1004
9.	Providence	1855	166	605
10.	2nd Albany	1856	381	722
11.	Montreal	1857	351	946
12.	Baltimore	1858	190	962
13.	Springfield	1859	190	862
14.	Newport	1860	135	644
15.	Buffalo	1866	79	687
16.	Burlington	1867	73	415
17.	Chicago	1868	259	686
18.	Salem	1869	244	511
19.	Troy	1870	188	536
20.	Indianapolis	1871	196	668
21.	Dubuque	1872	164	610
22.	Portland	1873	195	670
23.	Hartford	1874	224	722
24.	Detroit	1875	165	807
25.	2nd Buffalo	1876	215	867
26.	Nashville	1877	173	953
27.	St. Louis	1878	134	962
28.	Saratoga	1879	256	1030
29.	Boston	1880	997	1535
30.	2nd Cincinnati	1881	500	1699
31.	2nd Montreal	1882	937	1922
32.	Minneapolis	1883	328	2033
33.	2nd Philadelphia	1884	1261*	1981
34.	Ann Arbor	1885	364	1956
35.	3d Buffalo	1886	445	1886
36.	New York	1887	729	1959
37.	2nd Cleveland	1888	342	1964
38.	Toronto	1889	424	1952

*Including members of the British Association and other foreign guests.

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COMMONWEALTH OF MASSACHUSETTS.

IN THE YEAR ONE THOUSAND EIGHT HUNDRED AND SEVENTY-FO

AN ACT

To Incorporate the "American Association for th Advancement of Science."

Be it enacted by the Senate and House of Representatives, in General C assembled, and by the authority of the same, as follows:

Section 1. Joseph Henry of Washington, Benjamin Pierce of C bridge, James D. Dana of New Haven, James Hall of Albany, Al Caswell of Providence, Stephen Alexander of Princeton, Isaac Le Philadelphia, F. A. P. Barnard of New York, John S. Newberry of Cl land, B. A. Gould of Cambridge, T. Sterry Hunt of Boston, Asa Gra Cambridge, J. Lawrence Smith of Louisville, Joseph Lovering of C bridge and John LeConte of Philadelphia, their associates, the offi and members of the Association, known as the "American Associat for the Advancement of Science," and their successors, are hereby m a corporation by the name of the "American Association for Advancement of Science," for the purpose of receiving, purchasi holding and conveying real and personal property, which it now is hereafter may be, possessed of, with all the powers and privileges, subject to the restrictions, duties and liabilities set forth in the gen laws which now or hereafter may be in force and applicable to such porations.

Section 2. Said corporation may have and hold by purchase, gr gift or otherwise, real estate not exceeding one hundred thous dollars in value, and personal estate of the value of two hundred fifty thousand dollars.

Section 3. Any two of the corporators above named are her authorized to call the first meeting of the said corporation in the mo of August next ensuing, by notice thereof "by mail," to each membe the said Association.

Section 4. This act shall take effect upon its passage.

House of Representatives, March 10, 1
Passed to be enacted,
John E. Sanford, *Speaker.*

In Senate, March 17, 1874.
Passed to be enacted,
Geo. B. Loring, *President.*

March 19, 1874.
Approved,
W. B. Washbu

Secretary's Department,
Boston, April 8, 1874.
A true copy, Attest:
David Pulsifer,
Deputy Secretary of the Commonwealth.

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CONSTITUTION

OF THE

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Incorporated by Act of the General Court of the Commonwealth of Massachusetts.

Objects.

Article 1. The objects of the Association are, by periodical and migratory meetings, to promote intercourse between those who are cultivating science in different parts of America, to give a stronger and more general impulse and more systematic direction to scientific research, and to procure for the labors of scientific men increased facilities and a wider usefulness.

Members, Fellows, Patrons and Honorary Fellows.

Art. 2. The Association shall consist of Members, Fellows, Patrons, and Honorary Fellows.

Art. 3. Any person may become a Member of the Association upon recommendation in writing by two members or fellows, and election by the Council.

Art. 4. Fellows shall be elected by the Council from such of the members as are professionally engaged in science, or have by their labors aided in advancing science. The election of fellows shall be by ballot and a majority vote of the members of the Council at a designated meeting of the Council.

Art. 5. Any person paying to the Association the sum of one thousand dollars shall be classed as a Patron, and shall be entitled to all the privileges of a member and to all its publications.

Art. 6. Honorary Fellows of the Association, not exceeding three for each section, may be elected; the nominations to be made by the Council and approved by ballot in the respective sections before election by ballot in General Session. Honorary Fellows shall be entitled to all the privi-

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leges of Fellows and shall be exempt from all fees and assessments, and entitled to all publications of the Association issued after the date of their election.

ART. 7. The name of any member or fellow two years in arrears for annual dues shall be erased from the list of the Association, provided that two notices of indebtedness, at an interval of at least three months, shall have been given; and no such person shall be restored until he has paid his arrearages or has been reëlected. The Council shall have power to exclude from the Association any member or fellow, on satisfactory evidence that said member or fellow is an improper person to be connected with the Association, or has in the estimation of the Council made improper use of his membership or fellowship.

ART. 8. No member or fellow shall take part in the organization of, or hold office in, more than one section at any one meeting.

OFFICERS.

ART. 9. The Officers of the Association shall be elected by ballot in General Session from the fellows, and shall consist of a President, a Vice President from each section, a Permanent Secretary, a General Secretary, a Secretary of the Council, a Treasurer, and a Secretary of each Section; these, with the exception of the Permanent Secretary, shall be elected at each meeting for the following one, and, with the exception of the Treasurer and the Permanent Secretary, shall not be reëligible for the next two meetings. The term of office of Permanent Secretary shall be five years.

ART. 10. The President, or, in his absence, the senior Vice President present, shall preside at all General Sessions of the Association and at all meetings of the Council. It shall also be the duty of the President to give an address at a General Session of the Association at the meeting following that over which he presided.

ART. 11. The Vice Presidents shall be the chairmen of their respective Sections, and of their Sectional Committees, and it shall be part of their duty to give an address, each before his own section, at such time as the Council shall determine. The Vice Presidents may appoint temporary chairmen to preside over the sessions of their sections, but shall not delegate their other duties. The Vice Presidents shall have seniority in order of their continuous membership in the Association.

ART. 12. The General Secretary shall be the Secretary of all General Sessions of the Association, and shall keep a record of the business of

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these sessions. He shall receive the records from the Secretaries of the Sections, which, after examination, he shall transmit with his own records to the Permanent Secretary within two weeks after the adjournment of the meeting.

ART. 13. The Secretary of the Council shall keep the records of the Council. He shall give to the Secretary of each Section the titles of papers assigned to it by the Council. He shall receive proposals for membership and bring them before the Council.

ART. 14. The Permanent Secretary shall be the executive officer of the Association under the direction of the Council. He shall attend to all business not specially referred to committees nor otherwise constitutionally provided for. He shall keep an account of all business that he has transacted for the Association, and make annually a general report for publication in the annual volume of Proceedings. He shall attend to the printing and distribution of the annual volume of Proceedings, and all other printing ordered by the Association. He shall issue a circular of information to members and fellows at least three months before each meeting, and shall, in connection with the Local Committee, make all necessary arrangements for the meetings of the Association. He shall provide the Secretaries of the Association with such books and stationery as may be required for their records and business, and shall provide members and fellows with such blank forms as may be required for facilitating the business of the Association. He shall collect all assessments and admission fees, and notify members and fellows of their election, and of any arrearages. He shall receive, and bring before the Council, the titles and abstracts of papers proposed to be read before the Association. He shall keep an account of all receipts and expenditures of the Association, and report the same annually at the first meeting of the Council, and shall pay over to the Treasurer such unexpended funds as the Council may direct. He shall receive and hold in trust for the Association all books, pamphlets and manuscripts belonging to the Association, and allow the use of the same under the provisions of the Constitution and the orders of the Council. He shall receive all communications addressed to the Association during the interval between meetings, and properly attend to the same. He shall at each meeting report the names of fellows and members who have died since the preceding meeting. He shall be allowed a salary which shall be determined by the Council, and may employ one or more clerks at such compensation as may be agreed upon by the Council.

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ART. 15. The Treasurer shall invest the funds received by him in such securities as may be directed by the Council. He shall annually present to the Council an account of the funds in his charge. No expenditure of the principal in the hands of the Treasurer shall be made without a unanimous vote of the Council, and no expenditure of the income received by the Treasurer shall be made without a two-thirds vote of the Council.

ART. 16. The Secretaries of the Sections shall keep the records of their respective sections, and, at the close of the meeting, give the same, including the records of subsections, to the General Secretary. They shall also be the Secretaries of the Sectional Committees. The Secretaries shall have seniority in order of their continuous membership in the Association.

ART. 17. In case of a vacancy in the office of the President, one of the Vice Presidents shall be elected by the Council as the President of the meeting. Vacancies in the offices of Vice President, Permanent Secretary, General Secretary, Secretary of the Council, and Treasurer, shall be filled by nomination of the Council and election by ballot in General Session. A vacancy in the office of Secretary of a Section shall be filled by nomination and election by ballot in the Section.

ART. 18. The Council shall consist of the past Presidents, and the Vice Presidents of the last meeting, together with the President, the Vice Presidents, the Permanent Secretary, the General Secretary, the Secretary of the Council, the Secretaries of the Sections, and the Treasurer of the current meeting, with the addition of one fellow elected from each Section by ballot on the first day of its meeting. The members present at any regularly called meeting of the Council, provided there are at least five, shall form a quorum for the transaction of business. The Council shall meet on the day preceding each annual meeting of the Association, and arrange the programme for the first day of the sessions. The time and place of this first meeting shall be designated by the Permanent Secretary. Unless otherwise agreed upon, regular meetings of the Council shall be held in the council room at 9 o'clock, A.M., on each day of the meeting of the Association. Special meetings of the Council may be called at any time by the President. The Council shall be the board of supervision of the Association, and no business shall be transacted by the Association that has not first been referred to, or originated with, the Council. The Council shall receive and assign papers to the respective sections; examine and, if necessary, exclude papers; decide which papers,

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s and other proceedings shall be published, and have the general
of the publications of the Association; manage the financial
ne Association; arrange the business and programmes for Gen-
ons; suggest subjects for discussion, investigation or reports;
bers and fellows; and receive and act upon all invitations ex-
the Association and report the same at a General Session of
ation. The Council shall receive all reports of Special Com-
d decide upon them, and only such shall be read in General
the Council shall direct. The Council shall appoint at each
ne following sub-committees who shall act, subject to appeal
le Council, until their successors are appointed at the follow-
g: 1, on Papers and Reports; 2, on Members; 3, on Fellows.

The Nominating Committee shall consist of the Council, and
r or fellow elected by each of the Sections. It shall be the duty
mmittee to meet at the call of the President and nominate the
cers for the following meeting of the Association. It shall also
of this Committee to recommend the time and place for the
ng. The Vice President and Secretary of each Section shall
ended to the Nominating Committee by a sub-committee con-
the Vice President, Secretary, and three members or fellows
the Section.

Meetings.

The Association shall hold a public meeting annually, for one
nger, at such time and place as may be determined by vote of
ation, and the preliminary arrangements for each meeting shall
the Local Committee, in conjunction with the Permanent Sec-
such other persons as the Council may designate.

A General Session shall be held at 10 o'clock A. M., on the first
meeting, and at such other times as the Council may direct.

Sections and Subsections.

The Association shall be divided into Sections, namely:—
atics and Astronomy; B, *Physics;* C, *Chemistry, including its*
to agriculture and the arts; D, *Mechanical Science and Engi-*
, Geology and Geography; F, *Biology*; [G, united to section F];
pology; I, *Economic Science and Statistics.* The Council shall
er to consolidate any two or more Sections temporarily, and
olidated Sections shall be presided over by the senior Vice Pres-
Secretary of the Sections comprising it.

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ART. 23. Immediately on the organization of a Section there shall be three fellows elected by ballot after open nomination, who, with the Vice President and Secretary, shall form its Sectional Committee. The Sectional Committees shall have power to fill vacancies in their own numbers. Meetings of the Sections shall not be held at the same time with a General Session.

ART. 24. The Sectional Committee of any Section may at its pleasure form one or more temporary Subsections, and may designate the officers thereof. The Secretary of a Subsection shall, at the close of the meeting, transmit his records to the Secretary of the Section.

ART. 25. A paper shall not be read in any Section or Subsection until it has been received from the Council and placed on the programme of the day by the Sectional Committee.

SECTIONAL COMMITTEES.

ART. 26. The Sectional Committees shall arrange and direct the business of their respective Sections. They shall prepare the daily programmes and give them to the Permanent Secretary for printing at the earliest moment practicable. No titles of papers shall be entered on the daily programmes except such as have passed the Council. No change shall be made in the programme for the day in a Section without the consent of the Sectional Committee. The Sectional Committees may refuse to place the title of any paper on the programme; but every such title, with the abstract of the paper or the paper itself, must be returned to the Council with the reasons why it was refused.

ART. 27. The Sectional Committees shall examine all papers and abstracts referred to the sections, and they shall not place on the programme any paper inconsistent with the character of the Association; and to this end they have power to call for any paper, the character of which may not be sufficiently understood from the abstract submitted.

PAPERS AND COMMUNICATIONS.

ART. 28. All members and fellows must forward to the Permanent Secretary, as early as possible, and when practicable before the convening of the Association, full titles of all the papers which they propose to present during the meeting, with a statement of the time that each will occupy in delivery, and also such abstracts of their contents as will give a general idea of their nature; and no title shall be referred by the Council to the Sectional Committee until an abstract of the paper or the paper itself has been received.

ART. 29. If the author of any paper be not ready at the time assigned, the title may be dropped to the bottom of the list.

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ART. 30. Whenever practicable, the proceedings and discussions at General Sessions, Sections and Subsections shall be reported by professional reporters, but such reports shall not appear in print as the official reports of the Association unless revised by the Secretaries.

PRINTED PROCEEDINGS.

ART. 31. The Permanent Secretary shall have the Proceedings of each meeting printed in an octavo volume as soon after the meeting as possible, beginning one month after adjournment. Authors must prepare their papers or abstracts ready for the press, and these must be in the hands of the Secretaries of the Sections before the final adjournment of the meeting, otherwise only the titles will appear in the printed volume. The Council shall have power to order the printing of any paper by abstract or title only. Whenever practicable, proofs shall be forwarded to authors for revision. If any additions or substantial alterations are made by the author of a paper after its submission to the Secretary, the same shall be distinctly indicated. Illustrations must be provided for by the authors of the papers, or by a special appropriation from the Council. Immediately on publication of the volume, a copy shall be forwarded to every member and fellow of the Association who shall have paid the assessment for the meeting to which it relates, and it shall also be offered for sale by the Permanent Secretary at such price as may be determined by the Council. The Council shall also designate the institutions to which copies shall be distributed.

LOCAL COMMITTEE.

ART. 32. The Local Committee shall consist of persons interested in the objects of the Association and residing at or near the place of the proposed meeting. It is expected that the Local Committee, assisted by the officers of the Association, will make all essential arrangements for the meeting, and issue a circular giving necessary particulars, at least one month before the meeting.

LIBRARY OF THE ASSOCIATION.

ART. 33. All books and pamphlets received by the Association shall be in the charge of the Permanent Secretary, who shall have a list of the same printed and shall furnish a copy to any member or fellow on application. Members and fellows who have paid their assessments in full shall be allowed to call for books and pamphlets, which shall be delivered to them at their expense, on their giving a receipt agreeing to make good any loss or damage and to return the same free of expense to the Secretary at the time specified in the receipt given. All books and pamphlets

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in circulation must be returned at each meeting. Not more than five books, including volumes, parts of volumes, and pamphlets, shall be held at one time by any member or fellow. Any book may be withheld from circulation by order of the Council.

Admission Fee and Assessments.

Art. 34. The admission fee for members shall be five dollars in addition to the annual assessment. On the election of any member as a fellow an additional fee of two dollars shall be paid.

Art. 35. The annual assessment for members and fellows shall be three dollars.

Art. 36. Any member or fellow who shall pay the sum of fifty dollars to the Association, at any one time, shall become a Life Member and as such shall be exempt from all further assessments, and shall be entitled to the Proceedings of the Association. All money thus received shall be invested as a permanent fund, the income of which, during the life of the member, shall form a part of the general fund of the Association; but, after his death, shall be used only to assist in original research, unless otherwise directed by unanimous vote of the Council.

Art. 37. All admission fees and assessments must be paid to the Permanent Secretary, who shall give proper receipts for the same.

Accounts.

Art. 38. The accounts of the Permanent Secretary and of the Treasurer shall be audited annually, by Auditors appointed by the Council.

Alterations of the Constitution.

Art. 39. No part of this Constitution shall be amended or annulled, without the concurrence of three-fourths of the members and fellows present in General Session, after notice given at a General Session of a preceding meeting of the Association.

ORDER OF PROCEEDINGS IN ORGANIZING A MEETING.

1. The retiring President introduces the President elect, who takes the chair.
2. Formalities of welcome of the Association as may be arranged by the Local Committee.
3. Report of the list of papers entered and their reference to the Sections.
4. Other reports.
5. Announcements of arrangements by the Local Committee.
6. Announcements of Elections by the Council.
7. Unenumerated business.
8. Adjournment to meet in Sections.

This order, so far as applicable, to be followed in subsequent General Sessions.

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MEMBERS

OF THE

AMERICAN ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE.[1]

PATRONS.[2]

THOMPSON, MRS. ELIZABETH, Stamford, Conn. (22).
LILLY, GEN. WILLIAM, Mauch Chunk, Carbon Co., Pa. (28) F E
HERRMAN, MRS. ESTHER, 59 West 56th St., New York, N. Y. (29).

MEMBERS.[3]

Abbe, Robert, 11 W. 50th St., New York, N. Y. (36).
Abert, S. Thayer, 810 19th St., N. W., Washington, D. C. (30). A B D E I
Abrey, George Burchutt, C.E., Toronto, Ontario, Can. (38).
Adams, W. H., Consulting Engineer, 71 Wall St., New York, N. Y. (36).
Agard, Dr. A. H., 1259 Alice St., Oakland, Alameda Co., Cal. (28).
Alden, Jno., Pacific Mills, Lawrence, Mass. (36).

[1] The numbers in parentheses indicate the meeting at which the member was elected. The black letters at the end of line indicate the sections to which members elect to belong. The Constitution requires that the names of all members two or more years in arrears shall be omitted from the list, but their names will be restored on payment of arrearages. Members not in arrears are entitled to the annual volume of Proceedings bound in paper. *The payment of ten dollars at one time entitles a member to the subsequent volumes to which he may be entitled, bound in cloth, or by the payment of twenty dollars, to such volumes bound in half morocco.*

[2] Persons contributing one thousand dollars or more to the Association are classed as Patrons, and are entitled to the privileges of members and to the publications.

The names of Patrons are to remain permanently on the list.

[3] Any Member or Fellow may become a Life Member by the payment of fifty dollars. The income of the money derived from a Life Membership is used for the general purposes of the Association during the life of the member; afterwards it is to be used to aid in original research. Life Members are exempt from the annual assessment, and are entitled to the annual volume. The names of Life Members are printed in small capitals in the regular list of Members and Fellows.

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Allderdice, Wm. H., Ass't Eng. U. S. N., U. S. Naval Academy, Annapolis, Md. (33). D
Allen, Addison, 50 Wall St., New York, N. Y. (36).
Allen, Dudley P., M.D., 278 Prospect St., Cleveland, Ohio (36) F
Allen, J. M., Hartford, Conn. (22). D
Allen, W. F., 46 Bond St., New York, N. Y. (36).
Alvord, Benjamin, 2nd Lt., U. S. A., West Point, N. Y. (33). A
Ammidown, Edward H., P. O. Box 2739, New York, N. Y. (37).
Anderson, Alexander D., Washington, D. C. (38).
Anderson, Newton M., 371 Sibley St., Cleveland, Ohio (30). B
Angell, Geo. W. J., 44 Hudson St., New York, N. Y. (36).
Ansley, Clark F., Swedona, Mercer Co., Ill. (32). E H
Antiseli, Thomas, M.D., 1311 Q St., N. W., Washington, D. C. (33) C E
Appleton, Rev. Edw. W., D.D., Ashbourne P. O., Montgomery Co., Pa. (28).
Archambault, U. E., P. O. Box 1944, Montreal, P. Q., Can. (31).
Ashley, Prof. William James, 29 Harbord St., Toronto, Ontario, Can. (38).
Atkinson, Jno. B., Earlington, Hopkins Co., Ky. (26). D
Atterbury, Rev. Anson Phelps, 117 W. 87th St., New York, N. Y. (36). E
Atwell, Charles B., 461 Emerson St., Evanston, Ill. (36). F
Atwood, E. S., East Orange, N. J. (29). F
Austin, Wm., Belvidere House, 4th Ave., cor. 18th St., New York, N. Y. (36).
Avery, Samuel P., 4 E. 38th St., New York, N. Y. (36).
Ayer, Edward Everett, Room 12, The Rookery, Chicago, Ill. (37). H

Baba, Tatui (36). H
Babcock, Geo. H., 30 Cortlandt St., New York, N. Y. (33). D
Bacon, Prof. Chas. A., Observatory Beloit College, Beloit, Wis. (36) A
Bain, James, jr., Toronto, Ontario, Can. (38).
Baker, Richard D., 1414 Arch St., Philadelphia, Pa. (33). E C
Baker, Wm. G., 234 E. 15th St., New York, N. Y. (36).
Balderston, C. Canby, Westtown, Chester Co., Pa. (33). B
Baldwin, Judge Charles C., 1264 Euclid Ave., Cleveland, Ohio (37). H I
Baldwin, Miss Mary A., 28 Fulton St., Newark, N. J. (31). E
Baldwin, Mrs. G. H., 3 Madison Ave., Detroit, Mich. (34). H
Ballard, Harlan H., 50 South St., Pittsfield, Mass. (31). E F
Balliard, Chas., Metropolitan Museum of Art, New York, N. Y. (36).
Banes, Charles H., 2021 Spring Garden St., Philadelphia, Pa. (31). D
Bangs, Lemuel Bolton, M.D., 127 E. 34th St., New York, N. Y. (36).
Barber, D. H., Marion, Iowa (37).
Barclay, Robert, A.M., M.D., 3211 Lucas Ave., St. Louis, Mo. (30).
Bardeen, Francis L., M.D., Box 76, Onondaga Hill, N. Y. (32). C F B
Barge, B. F., Mauch Chunk, Pa. (33).
Barker, Mrs. Martha M., 26 Eleventh St., Lowell, Mass. (31). E H
Barnum, Miss Charlotte C., 144 Humphrey St., New Haven, Conn. (36). A
Bartlett, John W., M.D., 149 W. 94th St., New York, N. Y. (36).

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Bartley, Elias H., M.D., 21 Lafayette Ave., Brooklyn, N. Y. (33). C
Bates, Prof. Clinton Owen, Cedar Rapids, Iowa (38).
Bates, Wm. W., 31 Exchange Building, Buffalo, N. Y. (38).
Battershall, Jesse Park, 402 Washington St., New York, N. Y. (36).
Batterson, J. G., Hartford, Conn. (23).
Baur, George, New Haven, Conn. (36).
Baxter, James N., 18 Fulton St., Brooklyn, N. Y. (36).
Baxter, Sylvester, office of the Herald, Boston, Mass. (36). H
Beach, William H., Madison, Wis. (21). E B
Bean, Thos. E., Box 441, Galena, Ill. (28). F
Beardslee, H. C., 801 Wilson Ave., Cleveland, Ohio (37). F
Bechdolt, Adolphus F., Supt. City Schools, Mankato, Minn. (32). E B F
Becker, Dr. Geo. F., U. S. Geol. Survey, San Francisco, Cal. (36). E
Bell, C. M., M.D., 320 Fifth Ave., New York, N. Y. (36).
Benjamin, E. B., 6 Barclay St., New York, N. Y. (19). B C
Benns, Chas. P., Schenectady, N. Y. (38). D
Beveridge, David, 145 Griswold St., Detroit, Mich. (33). I
Bien, Julius, 139 Duane St., New York, N. Y. (34). E H
Bigelow, Otis, 605 7th St., Washington, D. C. (30). H F
Bigelow, Robert P., Washington, D. C. (32). F E
Bingham, Mrs. Martha A., Hotel Brunswick, Kansas City, Mo. (32).
Birdsall, Miss Louise W., 105 E. 37th St., New York, N. Y. (37). F E
Birge, Charles P., Keokuk, Iowa (29). E
Bishop, Heber R., Mills Building, New York, N. Y. (36).
Bixby, Wm. H., Wilmington, N. C. (34). D
Blackstock, Rev. W. S., 20 Homewood Ave., Toronto, Ont., Can. (38). E
Blackwell, Mrs. A. B., Elizabeth, N. J. (30). F C B
Blake, L. I., Hyde Park, Mass. (36).
Blakslee, Prof. T. M., North Des Moines, Iowa (31). A
Blatchford, Ellphalet W., 375 La Salle Ave., Chicago, Ill. (17). F
Bleile, Albert M., M.D., 342 S. Fourth St., Columbus, Ohio (37) F
Blish, W. G., Niles, Mich. (33). B D
Blount, Henry F., University Park, Washington, D. C. (32). I B
Blount, Mrs. Lucia E., Univ. Park, Washington, D. C. (34). H I
Blue, Archibald, Ass't Minister of Agric., Toronto, Can. (35). I
Boardman, William Dorr, 38 Kenilworth St., Roxbury, Mass. (38). E
Bohannan, R. W., University of Virginia, Va. (36).
Bolton, Prof. John, 49 Huntington St., Cleveland, Ohio (37).
Booraem, J. V. V., 204 Lincoln Place, Brooklyn, N. Y. (36).
Booth, Miss Mary A., Longmeadow, Mass. (34). F I
Booth, Samuel C., Longmeadow, Mass. (34). E I
Bothwell, Geo. W., M.A., Oakland, Cal. (36).
Bourland, Addison M., M.D., Van Buren, Ark. (29). C E F
Boustead, W. E., Toronto, Ontario, Can. (38).
Bowers, Miss Virginia K., 61 Taylor St., Newport, Ky. (27). F H B C
Bowman, Chas. G., Lt. U. S. N., Naval Acad., Annapolis, Md. (33).
Bowser, Mrs. Anna C., 328 Third St., Louisville, Ky. (33). H

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Boyer, Jerome L., Sup't Chestnut Hill Iron Ore Co., Reading, Pa. (35). D
Brackett, Richard N., Chemist of the Geological Survey of Arkansas, Little Rock, Ark. (37). C E
Bradford, Royal B., Commander U. S. N., care of Navy Department, Washington, D. C. (31). B D
Braid, James W., Nashville, Tenn. (33).
Bray, Prof. C. D., College Hill, Mass. (29). D B
Brayton, Miss Sarah H., M.D., Evanston, Ill. (33).
Breckinridge, S. M., P. O. Box 346, St. Louis, Mo. (27).
Brice, Judge Albert G., 19 Camp St., New Orleans, La. (32). H
Brill, Prof. Charles C., Northfield, Vt. (36). F
Bristol, Wm. H., Stevens Institute, Hoboken, N. J. (36). A B D
Bromfield, Rev. Edw. T., Glenbrook, Fairfield Co., Conn. (33). F H
Brooke, Dr. Emma W., 15th and Chestnut Sts., Phila., Pa. (33). C E
Brooks, Prof. Wm. P., Amherst, Mass. (38). C F
Broomall, Hon. John M., Media, Delaware Co., Pa. (23). A
Brown, Albert P., Ph.D., 501 Federal St., Camden, N. J. (33). F C
Brown, Fred. G., Fort Ann, Washington Co., N. Y. (31). C E
Brown, Henry A., Saxonville, Mass. (38). I
Brown, Rev. Henry M., East Aurora, Erie Co., N. Y. (35). F C
Brown, Jonathan, 390 Broadway, Somerville, Mass. (29).
Brown, Paul Taylor, 2206 Green St., Philadelphia, Pa. (33). E
Brownell, Silas B., 71 Wall St., New York, N. Y. (36).
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West, Miss Nellie B., 56 West 55th St., New York, N. Y. (38). H
Westbrook, Benj. F., M.D., 174 Clinton St., Brooklyn, N. Y. (33).
Wetzler, Jos., Room 175, Potter Building, New York, N. Y. (36).
Wheeler, Arthur S., Tulane Univ., New Orleans, La. (36).
Wheeler, Herbert A., Washington Univ., St. Louis, Mo. (33). E I
Wheeler, Moses D., M.E., P. O. Box 539, Stapleton, Staten Island, N. Y. (35). D
Wheeler, T. B., M.D., 194 Mountain St., Montreal, P. Q., Can. (11).
Wheildon, Miss Alice W., Concord, Mass. (31).
Whelen, Edw. S., 1520 Walnut St., Philadelphia, Pa. (33).
Whetstone, John L., Summit Ave., Mt. Auburn, Cincinnati, Ohio (30). D
White, Charles H., Med. Inspector U.S.N., Mus. of Hygiene, 1709 N. Y. Ave., N. W., Washington, D. C. (34). C
White, James G., Kearney, Neb. (34). B A
White, LeRoy S., Box 324, Waterbury, Conn. (28).
White, Loomis L., 7 E. 44th St., New York, N. Y. (36).
White, Z. L., Washington, D. C. (37). I
Whiting, S. B., 24 Highland Ave., Cambridgeport, Mass. (33). D
Whitlock, Prof. Roger H., Coll. Station, Brazos Co., Texas (36). A B D

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Wilbour, Mrs. Charlotte B., Little Compton, R. I. (28).
Wilcox, Miss Emily T., 85 Second St., Troy, N. Y. (33). B A
Wilder, Alex., M.D., 565 Orange St., Newark, N. J. (29). H F I
Wilkinson, J. Henderson, 320 E. Capitol St., Washington, D. C. (35). E
Wilkinson, Mrs. L. V., Seventy Six P. O., Perry Co., Mo. (30).
Willet, Joseph Edgerton, Macon, Ga. (36). E
Willetts, Joseph C., Skaneateles, N. Y. (29). E F H
Williams, C. T., 871 Case Ave., Cleveland, Ohio (37).
Williams, Prof. Edward H., jr., Box 463, Bethlehem, Pa. (25). E D
Williams, Francis H., M.D., Hotel Victoria, Boston, Mass. (29).
Williams, J. Francis, Salem, N. Y. (31). C E
Willis, Bailey, U. S. Geol. Survey, Washington, D. C. (36).
Willmott, Arthur B., Antioch College, Yellow Springs, Ohio (38).
Willson, Robert W., Cambridge, Mass. (30). B A
Wilmot, Thos. J., Commercial Cable Co., Waterville, County Kerry, Ireland (27). B
Wilson, Prof. Edmund B., Bryn Mawr, Pa. (36).
Wilson, James M., Riverton, Ill. (33).
Winchell, Horace V., 10 State St., Minneapolis, Minn. (34). E C
Winchell, Martin R., 120 Nassau St., New York, N. Y. (36). I
Wing, Henry H., Cornell Univ., Experimental Station, Ithaca, N. Y. (38).
Wingate, Miss Hannah S., 12 W. 125th St., New York, N. Y. (31). E I
Winterburn, Geo. Wm., M.D., 29 W. 26th St., New York, N. Y. (36). F H
Winterhalter, A. G., Lt. U. S. N., U. S. Naval Observ., Washington, D. C. (37). A
Wisser, John P., 1st Lieutenant, 1st Artillery, U. S. A., West Point, N. Y. (33). C
Withers, Prof. W. A., Agric. Mechanical College, Raleigh, N. C. (38). C
Witthaus, Dr. R. A., 410 E. 26th St., New York, N. Y. (35).
Witton, James G., B.A., University Coll,, Toronto, Ontario, Can. (38). B
Wolcott, Mrs. Henrietta L. T., Dedham, Mass. (29).
Wolf, Theo. R., Ph.D., Newark, Delaware (36).
Wolff, Dr. J. E., 15 Story St., Cambridge, Mass. (36).
Wood, Alvinus B., 980 Jefferson Ave., Detroit, Mich. (34). E
Wood, Harry A., M.D., State Insane Asylum, Buffalo, N. Y. (35).
Wood, Joseph S., Mount Vernon, Westchester Co., N. Y. (36).
Wood, Norman B., jr., 67½ University St., Cleveland, Ohio (38).
Wood, Dr. Robert W., Jamaica Plain, Mass. (29).
Wood, Walter, 400 Chestnut St., Philadelphia, Pa. (33). F I
Wood, Dr. William B., 17 E. 38th St., New York, N. Y. (36).
Woodford, Prof. A. B., Indiana Univ., Bloomington, Ind. (36). I
Worthington, George, Editor Electrical Review, 13 Park Row, New York, N. Y. (36). B D
Wright, Prof. R. Ramsey, Toronto, Ontario, Can. (38). F
Wright, Rufus, 333–339 Lake St., Chicago, Ill. (37). B
Würtele, Miss Minnie, Acton Vale, P. Q., Can. (32). H
Wyman, Walter Channing, 158 Dearborn St., Chicago, Ill. (34). H

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Youmans, Mrs. Celia G., Mount Vernon, N. Y. (86).
Young, Prof. A. Harvey, Hanover College, Hanover, Ind. (80). F C
Young, Archibald Hope, Upper Canada College, Toronto, Ontario, Can. (88).

Zalinski, E. L., Cap't 5th Art'y, U. S. A., Fort Hamilton, New York Harbor, N. Y. (86).
Ziwet, Alexander, Univ. of Michigan, Ann Arbor, Mich. (88). A

[1232 PATRONS AND MEMBERS.]

NOTE.—The omission of an address in the foregoing list indicates that letters directed to that last printed were returned as uncalled for. Information of the present address of the members so indicated is requested by the PERMANENT SECRETARY.

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HONORARY FELLOWS.[1]

ROGERS, WILLIAM B., Boston, Mass. (1). 1881. (Born Dec. 7, 1804. Died May 30, 1882.) **B E**

CHEVREUL, MICHEL EUGÈNE, Paris, France (35). 1886. (Born Aug. 31, 1786. Died April 9, 1889.)

GENTH, DR. F. A., 3937 Locust St., Philadelphia, Pa. (24). 1875. 1888. **C E**

FELLOWS.[2]

Abbe, Professor Cleveland, Army Signal Office, Washington, D. C. (16). 1874. **B A**

Abbott, Dr. Chas. C., Trenton, N. J. (29). 1883. **F H**

Adams, Frank Dawson, 141 Rideau St., Ottawa, Ontario, Can. (29). 1885.

Alden, Prof. Geo. I., Worcester, Mass. (33). 1885. **D**

Alexander, John S., Texas Nat'l Bank, San Antonio, Texas (20). 1874. **B C D**

Allen, Dr. Harrison, 117 S. 20th St., Philadelphia, Pa. (29). 1882. **F**

Allen, Joel A., American Museum of Natural History, Central Park, New York (18). 1875. **F**

Allen, Dr. T. F., 10 E. 36th St., New York, N. Y. (35). 1887. **F**

Alvord, Major Henry E., Agricultural College, Md. (29). 1882. **I**

Ammen, Daniel, Rear Admiral U. S. Navy, Beltsville, Md. (26). 1881. **E**

Anderson, Dr. Joseph, Waterbury, Conn. (29). 1883. **H**

Anthony, Prof. Wm. A., Manchester, Conn. (28). 1880. **B**

Arey, Albert L., Free Academy, Rochester, N. Y. (35).

Arthur, J. C., La Fayette, Ind. (21). 1883. **F**

Ashburner, Charles A., Penn Building, Pittsburgh, Pa. (31). 1883. **E**

Atkinson, Edward, 31 Milk St., Boston, Mass. (29). 1881. **I D**

Atwater, Prof. W. O., Wesleyan Univ., Middletown, Conn. (29). 1882. **C**

Auchincloss, Wm. S., 209 Church St., Philadelphia, Pa. (29). 1886. **D A**

Avery, Elroy M., Ph.D., Woodland Hills Ave., Cleveland, Ohio (37). 1889. **B**

Ayers, Howard (34). 1886. **F**

Ayres, Prof. Brown, Tulane University, New Orleans, La. (31). 1885. **B**

Babbitt, Miss Franc E., Lock Box 1284, Coldwater, Mich. (32). 1887. **H I**

Babcock, S. Moulton, Madison, Wis. (33). 1885. **C**

Bailey, E. H. S., Lawrence, Douglas Co., Kan. (25). 1889. **C E**

Bailey, Prof. Liberty H., Ithaca, N. Y. (34). 1887. **F**

[1] See ARTICLE VI of the Constitution. [2] See ARTICLE IV of the Constitution.

*** The number in parenthesis indicates the meeting at which the member joined the Association; the date following is the year when made a Fellow; the black letters at end of line are those of the sections to which the fellow belongs.

When the name is given in small capitals, it designates that the Fellow is also a Life Member, and is entitled to the Annual Volume of Proceedings.

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Bailey, Prof. Loring W., University of Fredericton, N. B. (18). 1875.
Bailey, Prof. W. W., Brown University, Providence, R. I. (18). 1874. **F**
Baker, Frank, M.D., 1315 Corcoran St., Washington, D. C. (31). 1886. **F H**
Baker, Marcus, U. S. Geological Survey, Washington, D. C. (30). 1882. **A**
Barker, Prof. G. F., Univ. of Penn., Philadelphia, Pa. (13). 1875. **B C**
Barnard, Edward E., Lick Observ., San José, Cal. (26). 1883. **A**
Barnes, Prof. Chas. R., Madison, Wis. (33). 1885. **F**
Bartlett, Prof. Edwin J., Dartmouth College, Hanover, N. H. (28). 1883. **C**
Bartlett, John R., Commander U. S. N., Navy Dep't, Washington, D. C. (30). 1882. **E B**
Barus, Carl, Ph.D., U. S. Geol. Survey, Washington, D. C. (33). 1887. **B**
Bassett, Homer F., Waterbury, Conn. (23). 1874. **F**
Batchelder, John M., 3 Divinity Avenue, Cambridge, Mass. (8). 1875. **B D I**
Bates, Henry Hobart, U. S. Patent Office, Washington, D. C. (33). 1887. **B A C D**
Battle, Herbert B., Ph.D., Director N. C. Agric. Exper. Station, Raleigh, N. C. (33). 1889. **C**
Bausch, Edward, Rochester, N. Y. (26). 1883. **A B C F**
Baylor, James B., U. S. Coast and Geodetic Survey Office, Washington, D. C. (33). 1888. **A**
Beal, Prof. Wm. James, Agricultural College, Ingham Co., Mich. (24). 1880. **F**
Beardsley, Prof. Arthur, Swarthmore College, Swarthmore, Del. Co., Pa. (33). 1885. **D**
Beauchamp, Rev. Wm. M., Baldwinsville, N. Y. (34). 1886. **H**
Bell, Dr. Alex. Graham, Scott Circle, 1500 Rhode Island Ave., Washington, D. C. (26). 1879. **B H I**
Bell, Alex. Melville, 1525 35th St., Washington, D. C. (31). 1885. **H**
Bell, Robert, LL.D., Ass't Director Geological Survey, Ottawa, Ontario, Can. (38). 1889. **E F**
Beman, Wooster W., 19 So. 5th St., Ann Arbor, Mich. (34). 1886. **A**
Benjamin, Marcus, 15 W. 121st St., New York, N. Y. (27). 1887. **C**
Benjamin, Rev. Raphael, M.A., 1334 Lexington Ave., New York, N. Y. (34). 1887. **F A B D E H I**
Bennett, Prof. Wm. Z., Wooster, Wayne Co., Ohio (33). 1889. **C**
Bessey, Prof. Charles E., Univ. of Nebraska, Lincoln, Neb. (21). 1880. **F**
Bethune, Rev. C. J. S., Trinity College School, Pt. Hope, Ont., Can. (18). 1875. **F**
Beyer, Dr. Henry G., U. S. N., U. S. National Museum, Washington, D. C. (31). 1884. **F**
Bickmore, Prof. Albert S., American Museum of Natural History, 8th Ave. and 77th St., Central Park, New York, N. Y. (17). 1880. **H**
Bigelow, Prof. Frank H., Racine, Wis. (36) 1888. **A**

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Billings, John S., Surgeon U. S. A., Surg. General's Office, Washington, D. C. (32). 1883. **F H**

Blackham, George E., M.D., Dunkirk, N. Y. (25). 1883. **F**

Blake, Clarence J., M.D., 226 Marlborough St., Boston, Mass. (24). 1877. **B F**

Blake, Prof. Eli W., Brown Univ., Providence, R. I. (15). 1874. **B**

Blake, Francis, Auburndale, Mass. (23). 1874. **B A**

Blake, Francis C., Mansfield Valley P. O., Allegheny Co., Pa. (29). 1889. **C B D**

Boardman, Mrs. William D., 38 Kenilworth St., Roxbury, Mass. (28). 1885. **E H**

Boas, Dr. Franz, 196 Third Ave., New York, N. Y. (36) 1888. **H**

Boerner, Chas. G., Vevay, Switzerland Co., Ind. (29). 1886. **A B E**

Bolton, Dr. H. Carrington, University Club, New York, N. Y. (17). 1875. **C**

Bond, Geo. M., care of The Pratt & Whitney Co., Hartford, Conn. (33). 1885. **D**

Borden, Spencer, Fall River, Mass. (29). 1882. **B C I**

Boss, Prof. Lewis, Director Dudley Observ., Albany, N. Y. (26). 1878.

Bourke, John G., Capt. 3d Cavalry, U. S. A., War Dept., Washington, D. C. (33). 1885. **H**

Bouvé, Thos. T., Boston Soc. Nat. Hist., Boston, Mass. (1). 1875. **E**

Bowditch, Prof. H. P., Jamaica Plain, Mass. (28). 1880. **F B H**

Bowditch, Henry I., M.D., 113 Boylston St., Boston, Mass. (2). 1875. **F H**

Bowser, Prof. E. A., Rutgers College, New Brunswick, N. J. (28). 1881.

Brace, DeWitt B., Lincoln, Neb. (35). 1887. **B**

Brackett, Prof. C. F., College of New Jersey, Princeton, N. J. (19). 1875. **B**

Brackett, Solomon H., St. Johnsbury, Vt. (29). 1884. **B A**

Branner, John C., Director of the Geological Survey of Arkansas, Little Rock, Ark. (34). 1886. **E F**

Bransford, John Francis, Surgeon U. S. N., Smithsonian Institution, Washington, D. C. (36) 1888. **H I**

Brashear, Jno. A., Allegheny, Pa. (33). 1885. **A B D**

Brewer, Prof. Wm. H., New Haven, Conn. (20). 1875. **E F I**

Brewster, William, 61 Sparks St., Cambridge, Mass. (29). 1884. **F**

Brinton, D. G., M.D., 2014 Chestnut St., Philadelphia, Pa. (33). 1885. **H**

Britton, N. L., Columbia College, New York, N. Y. (29). 1882. **F E**

Broadhead, Garland Carr, Pleasant Hill, Cass Co., Mo. (27). 1879. **E**

Brooks, Wm. R., Box 714, Geneva, N. Y. (35). 1886. **A B D G**

Bross, Hon. Wm., Tribune Office, Chicago, Ill. (7). 1874. **E H**

Brown, Robert, care of Yale College Observatory, New Haven, Conn. (11). 1874.

Brown, Mrs. Robert, New Haven, Conn. (17). 1874.

Brühl, Gustav, cor. John and Hopkins Sts., Cincinnati, Ohio (28). 1886. **H**

Brush, Charles F., Brush Electric Light Co., Cleveland, Ohio (35). 1886. **B**

Brush, Prof. George J., Yale College, New Haven, Conn. (4). 1874. **C E**

Bryce, George, LL.D., Manitoba College, Winnipeg, Manitoba (38). 1889. **H**

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Buckhout, W. A., State College, Centre Co., Pa. (20). 1881. **F**
Burgess, Dr. Thomas J. W., Ass't Sup't Asylum, Hamilton, Ontario, Can. (38). 1889. **F**
Burr, Prof. William H., Phoenixville, Chester Co., Pa. (31). 1883.
Burrill, Prof. T. J., Univ. of Illinois, Champaign, Ill. (29). 1882. **F**
Butler, A. W., Brookville, Franklin Co., Ind. (30). 1885. **F H**

Caldwell, Prof. Geo. C., Cornell University, Ithaca, N. Y. (23). 1875. **C**
Calvin, Prof. Samuel, State Univ. of Iowa, Iowa City, Iowa (37). 1889. **B E**
Campbell, Douglas H., 91 Alfred St., Detroit, Mich. (34) 1888. **F**
Campbell, Edw. D. (34). 1887. **C**
Canby, William M., 1101 Delaware Avenue, Wilmington, Del. (17). 1878. **F**
Carhart, Prof. Henry S., University of Michigan, Ann Arbor, Mich. (29) 1881. **B**
Carmichael, Prof. Henry, 7 Broad St., Boston, Mass. (21). 1875. **C**
Carpenter, Louis G., Agricultural College, Fort Collins, Col. (32). 1889. **A B**
Carpenter, Capt. W. L., U. S. A., Dunkirk, N. Y. (24). 1877. **F E**
Carpmael, Charles, Director of Magnetic Observatory, Toronto, Ontario, Can. (31). 1883. **B**
Carr, Lucien, Peabody Museum Archæology and Ethnology, Cambridge, Mass. (25). 1877. **H**
Case, Col. Theo. S., Kansas City, Mo. (27). 1883. **H B**
Chamberlin, T. C., Madison, Wis. (21). 1877. **E B F H**
Chandler, Prof. C. F., School of Mines, Columbia Coll., East 49th St. cor. 4th Ave., New York, N. Y. (19). 1875. **C**
Chandler, Prof. Charles Henry, Ripon, Wis. (28). 1883. **A B**
Chandler, Seth C., jr., 16 Cragie St., Cambridge, Mass. (29). 1882. **A**
Chandler, Prof. W. H., South Bethlehem, Pa. (19). 1874. **C**
Chanute, O., Kansas City, Mo. (17). 1877. **D I**
Chapin, Dr. J. H., Meriden, Conn. (33). 1886. **E H**
Chester, Prof. Albert H., Hamilton College, Clinton, N. Y. (29). 1882. **C F**
Chester, Prof. Fred'k D., Del. State Coll., Newark, Del. (33). 1887. **E**
Chickering, Prof. J. W., jr., Deaf Mute College, Washington, D. C. (22). 1877. **F I**
Chute, Horatio N., Ann Arbor, Mich. (34). 1889. **B C A**
Clapp, Miss Cornelia M., Mt. Holyoke Seminary, South Hadley, Mass. (31). 1883. **F**
Clark, Alvan G., Cambridgeport, Mass. (28). 1880. **A B**
Clark, Prof. John E., Mathematics, Yale College, New Haven, Conn. (17). 1875. **A**
Clarke, Prof. F. W., U. S. Geological Survey, Washington, D. C. (18). 1874. **C**
Claypole, Prof. Edw. W., Buchtel Coll., Akron, Ohio (30). 1882. **E F**
Clayton, H. Helm, Readville, Mass. (34). 1887. **B**

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Cloud, John W., Buffalo, N. Y. (28). 1886. **A B D**
Coffin, Prof. Selden J., Lafayette College, Easton, Pa. (22). 1874. **A I**
Collett, Prof. John, Indianapolis, Ind. (17). 1874. **E**
Collingwood, Francis, Elizabeth, N. J. (36). 1888. **D**
Colvin, Verplanck, Supt. N. Y. State Adirondack Survey, Albany, N. Y. (28). 1880. **E**
Comstock, Prof. Geo. C., Washburn Observ., Univ. of Wisconsin, Madison, Wis. (34). 1887. **A**
Comstock, J. Henry, Cornell Univ., Ithaca, N. Y. (28). 1882. **F**
Comstock, Milton L., Knox College, Galesburg, Ill. (21). 1874. **A**
Comstock, Prof. Theo. B., Geol. Survey of Texas, Austin, Texas. (24). 1877. **D E B**
Cook, Prof. A. J., Agricultural College, Mich. (24). 1880. **F**
Cook, Chas. Sumner, Evanston, Ill. (36). 1889. **B**
Cooley, Prof. Le Roy C., Vassar College, Poughkeepsie, N. Y. (19). 1880. **B C**
Cooley, Prof. Mortimer E., Univ. of Michigan, Ann Arbor, Mich. (33). 1885. **D**
Cope, Prof. Edward D., 2100 Pine St., Philadelphia, Pa. (17). 1875. **F E**
Corthell, Elmer L., 205 La Salle St., Chicago, Ill. (34). 1886. **D**
Coulter, Prof. John M., Wabash College, Crawfordsville, Ind. (32). 1884. **F**
Cox, Prof. Edward T., 18 Cortlandt St., New York, N. Y. (19). 1874. **E**
Cox, Hon. Jacob D., Gilman Ave., Mt. Auburn, Cincinnati, Ohio (30). 1881. **F**
Coxe, Eckley B., Drifton, Luzerne Co., Pa. (23). 1879. **D E**
Crampton, Chas. A., Dept. of Agric., Washington, D. C. (36). 1887. **C**
Crandall, Prof. A. R., Lexington, Ky. (29). 1883. **E F**
Crawford, Prof. Morris B., Middletown, Conn. (30). 1889. **B**
Crocker, Susan E., M.D., Lawrence, Mass. (21). 1874. **E F**
Crosby, Prof. Wm. O., Boston Society of Natural History, Boston, Mass. (29). 1881. **E**
Cross, Prof. Chas. R., Mass. Institute Technology, Boston, Mass. (29). 1880. **B**
Cushing, Henry Platt, 786 Prospect St., Cleveland, Ohio (33). 1888. **E**
Cutting, Hiram A., M.D., State Geologist, Lunenburgh, Vt. (17). 1874. **E F**

Dabney, Chas. W., jr., Ph.D., Agricultural Experiment Station, Raleigh, N. C. (30). 1882. **C B E**
Dall, Mrs. Caroline H., 1630 O St., Washington, D. C. (18). 1874. **F H**
Dall, William H., Smithsonian Institution, Washington, D. C. (18). 1874. **H F**
Dana, Edward Salisbury, New Haven, Conn. (23). 1875. **B E**
Dana, Prof. James D., New Haven, Conn. (1). 1875. **E**
Davenport, B. F., M.D., 161 Tremont St., Boston, Mass. (29). 1883. **C**
Davidson, Prof. Geo., U. S. Coast and Geodetic Survey, San Francisco, Cal. (29). 1881. **A B D**

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Davis, Wm. Morris, Cambridge, Mass. (33). 1885. **E B**
Dawson, Sir William, Principal McGill College, Montreal, Can. (10). 1875. **E**
Day, David F., Buffalo, N. Y. (35). 1887. **F**
Day, F. H., M.D., Wauwatosa, Wis. (20). 1874. **E H F**
Dean, George W., P. O. Box 92, Fall River, Mass. (15). 1874. **A**
Denton, Prof. James E., Stevens Institute, Hoboken, N. J. (36). 1888. **D B A**
Dewey, Fred P., Ph.B., 621 F St. N. W., Washington, D. C. (30). 1886. **C E**
Diller, J. Silas, U. S. Geological Survey, Washington, D. C. (29). 1884. **E**
Dimmock, George, Cambridge, Mass. (22). 1874. **F**
Dodge, Charles R., Washington, D. C. (22). 1874.
Dodge, Prof. James A., University of Minnesota, Minneapolis, Minn. (29). 1884. **C E**
Dodge, J. Richards, Washington, D. C. (31). 1884. **I H**
Dolbear, A. Emerson, College Hill, Mass. (20). 1880. **B**
Doolittle, Prof. C. L., South Bethlehem, Pa. (25). 1885. **A**
Dorsey, Rev. J. Owen, Box 591, Washington, D. C. (31). 1883. **H**
Douglass, Andrew E., 63 Pine St., New York, N. Y. (31). 1885. **H**
Dow, Capt. John M., 83 W. 71st St., New York, N. Y. (31). 1884. **F H**
Draper, Dan'l, Ph. D., Director N. Y. Meteorological Observatory, Central Park, 64th St., Fifth Avenue, New York, N. Y. (29). 1881. **B D F A**
Drown, Prof. Thos. M., Mass. Institute Technology, Boston, Mass. (29). 1881. **C**
Du Bois, Prof. Aug. J., New Haven, Conn. (30). 1882. **A B D**
Du Bois, Patterson, Ass't Editor S.S.T., 1031 Walnut St., Philadelphia, Pa. (33). 1887. **H C I**
Dudley, Charles B., Altoona, Pa. (23). 1882. **C B D**
Dudley, P. H., 66½ Pine St., New York, N. Y. (29). 1884.
Dudley, Wm. L., Prof. of Chemistry, Vanderbilt Univ., Nashville, Tenn. (28). 1881. **C**
Dudley, Prof. Wm. R., Ithaca, N. Y. (29). 1883. **F**
Dunnington, Prof. F. P., University of Virginia, Va. (26). 1880. **C**
Dutton, Capt. C. E., U. S. Geol. Surv., Washington, D. C. (23). 1875.
Dwight, Prof. William B., Vassar College, Poughkeepsie, N. Y. (30). 1882. **E F**

Eastman, Prof. J. R., U. S. Naval Observatory, Washington, D. C. (26). 1879. **A**
Eaton, Prof. D. G., 55 Pineapple St., Brooklyn, N. Y. (19). 1874. **B E**
Eaton, Prof. James R., Liberty, Mo. (29). 1885. **C B E**
Eddy, Prof. H. T., Univ. of Cincinnati, Cincinnati, O. (24). 1875. **A B D**
Edison, Thos. A., Menlo Park, N. J. (27). 1878. **B**
Edmands, J. Rayner, Observatory, Cambridge, Mass. (29). 1880.

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Egleston, Prof. Thomas, 35 W. Washington Square, New York, N. Y. (27). 1879. **C D E**

Eimbeck, William, U. S. C. and G. S., Washington, D. C. (17). 1874. **A B D**

Elkin, William L., Yale Coll. Observ., New Haven, Conn. (33). 1885. **A**

Elliott, Arthur H., 591 Broadway, care Anthony's Bulletin, New York, N. Y. (23). 1880. **C**

Emerson, Prof. Benjamin K., Amherst, Mass. (19). 1877. **E F**

Emerson, Prof. C. F., Dartmouth Coll., Hanover, N. H. (22). 1874. **B A**

Emerton, James H., 11 St. James Ave., Boston, Mass. (18). 1875. **F**

Emery, Albert H., Stamford, Conn. (29). 1884. **D B**

Emery, Charles E., 22 Cortlandt St., New York, N. Y. (34). 1886. **D B A**

Emmons, S. F., U. S. Geol. Survey, Washington, D. C. (26). 1879. **E**

Engelmann, George J., M.D., 3003 Locust St., St. Louis, Mo. (25). 1875. **F H**

Evans, Asher B., 500 Pine St., Lockport, N. Y. (19). 1874. **A**

Ewing, Thomas, jr., Patent Office, Washington, D. C. (36). 1889. **B**

Eyerman, John, Easton, Pa. (33). 1889. **E C**

Fairbanks, Henry, Ph.D., St. Johnsbury, Vt. (14). 1874. **B D A**

Fairchild, Prof. H. L., University of Rochester, Rochester, N. Y. (28). 1883. **E F**

Fall, Prof. Delos, Albion College, Albion, Mich. (34). 1887. **C**

Fanning, John T., Consulting Eng., Great Northern Railway Building, St. Paul, Minn. (29). 1885. **D**

Farlow, Dr. W. G., 29 Holyoke House, Cambridge, Mass. (20). 1875. **F**

Farmer, Moses G., Eliot, Me. (9). 1875.

Farquhar, Henry, Coast Survey Office, Washington, D. C. (33). 1886. **A I F B**

Fernald, Prof. Charles H., Amherst, Mass. (22). 1881. **F E**

Fernald, Prof. M. C., State Agric. College, Orono, Me. (22). 1883. **B A**

Fernow, Bernhard E., Chief of Forestry Division, Dep't of Agriculture, Washington, D. C. (31). 1887. **F I**

Ferrel, Wm., 1641 Broadway, Kansas City, Mo. (11). 1875. **A B**

Fine, Prof. Henry B., Coll. of New Jersey, Princeton, N. J. (35). 1887. **A**

Firmstone, F., Easton, Pa. (33). 1887. **D**

Fitch, Edward H., Jefferson, Ashtabula Co., Ohio (11). 1874. **I E**

Fletcher, Miss Alice C., care Peabody Museum, Cambridge, Mass. (29). 1883. **H**

Fletcher, James, Dominion Entomologist, Ottawa, Ontario, Can. (31). 1883. **F**

Fletcher, Dr. Robert, Army Medical Museum, Washington, D. C. (29). 1881. **F H**

Flint, Albert S., Washburn Observ., Madison, Wis. (30). 1887. **A**

Flint, James M., Surgeon U. S. N., Smithsonian Institution, Washington, D. C. (28). 1882. **F**

Floyd, Richard S., 120 Sutter St., San Francisco, Cal. (34). 1889. **A**

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Foote, Dr. A. E., 1223 Belmont Ave., Philadelphia, Pa. (21). 1874. **E C**
Foye, Prof. J. C., Lawrence Univ., Appleton, Wis. (29). 1884. **C B**
Frazer, Dr. Persifor, 917 Clinton St., Philadelphia, Pa. (24). 1879. **E C**
Frazier, Prof. B. W., The Lehigh University, Bethlehem, Pa. (24). 1882. **E C**
Frear, Wm., State College, Centre Co., Pa. (33). 1886. **C**
French, Prof. Thomas, jr., Ridgeway Ave., Avondale, Cincinnati, Ohio (30). 1883. **B**
Frisby, Prof. Edgar, U. S. N. Observ., Washington, D. C. (28). 1880. **A**
Fuller, Andrew S., Ridgewood, Bergen Co., N. J. (24). 1882. **F**
Fulton, Prof. Robert B., University, Miss. (21). 1887. **B A**

Gaffield, Thomas, 54 Allen St., Boston, Mass. (29). 1889. **C B**
Gage, Simon Henry, Ithaca, N. Y. (28). 1881. **F**
Galbraith, Prof. John, Toronto, Ontario, Can. (38). 1889.
Gannett, Henry, U. S. Geological Survey, Washington, D. C. (33). 1884. **E I A**
Gardiner, James T., 21 Elk St., Albany, N. Y. (25). 1879. **E**
Garland, Rev. Dr. L. C., Chancellor Vanderbilt University, Nashville, Tenn. (25). 1877 **B**
Garman, Samuel, Museum Comparative Zoology, Cambridge, Mass. (20). 1874. **F E**
Gatschet, Dr. Albert S., Box 333, Washington, D. C. (30). 1882. **H**
Gibbs, Prof. J. Willard, New Haven, Conn. (33). 1885. **B**
Gilbert, G. K., Box 591, Washington, D. C. (18). 1874. **E**
Gill, Prof. Theo., Smithsonian Institution, Washington, D. C. (17). 1874.
Gillman, Henry, U. S. Consul, Jerusalem, Palestine, via England and Brindisi (24). 1875. **H F**
Gilman, Daniel C., President Johns Hopkins University, Baltimore, Md. (10). 1875. **E H**
Goessman, Prof. C. A., Mass. Agricultural College, Amherst, Mass. (18). 1875. **C**
Goff, E. S., Madison, Wis. (35). 1889.
Gold, Theodore S., West Cornwall, Conn. (4). 1887. **B C**
Goldschmidt, S. A., Ph.D., 55 Broadway, New York, N. Y. (24). 1880. **C E B**
Gooch, Frank A., Yale College, New Haven, Conn. (25). 1880. **C**
Goodale, Prof. G. L., Botanic Gardens, Cambridge, Mass. (18). 1875.
Goode, G. Brown, Curator Nat'l Museum, Washington, D. C. (22). 1874.
Goodfellow, Edward, Ass't U. S. Coast and Geodetic Survey, Washington, D. C. (24). 1879. **A H**
Gould, Dr. B. A., Cambridge, Mass. (2). 1875. **A B**
Grant, Mrs. Mary J., Brookfield, Conn. (23). 1874. **A**
Gratacap, L. P., Ph.B., 77th St. and 8th Ave., New York, N. Y. (27). 1884. **C E F**
Gray, Elisha, Sc.D., Highland Park, Ill. (32). 1883. **B**
Gray, Prof. Thomas, Terre Haute, Ind. (38). 1889.

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Green, Arthur L., La Fayette, Ind. (33). 1888. C
Green, Traill, M.D., Easton, Pa. (1). 1874. C F
Grimes, J. Stanley (17). 1874. E H
Grinnell, George Bird, 40 Park Row, New York, N. Y. (25). 1885. F E
Gulley, Prof. Frank A., College Station, Texas (30). 1883.

Hagen, Dr. Hermann A., Museum Comparative Zoology, Cambridge, Mass. (17). 1875. F
Hague, Arnold, U. S. Geol. Survey, Washington, D. C. (26). 1879.
Haines, Reuben, Haines and Chew St., Germantown, Philadelphia, Pa. (27). 1889. C B
Hale, Albert C., Ph.D., No. 551 Putnam Ave., Brooklyn, N. Y. (29). 1886. C B
Hale, Horatio, Clinton, Ontario, Can. (30). 1882. H
Hall, Prof. Asaph, U. S. Naval Observatory, Washington, D. C. (25). 1877. A
Hall, Prof. C. W., 803 Univ. Ave. So., Minneapolis, Minn. (28). 1883. E
Hall, Prof. Edwin H., 5 Avon St., Cambridge, Mass. (29). 1881. B
Hall, Prof. James, Albany, N. Y. (1). 1875. E F
Hall, Prof. Lyman B., Haverford College, Pa. (31). 1884. C
Halsted, Byron D., New Jersey Agricultural Experiment Station, New Brunswick, N. J. (29). 1883. F
Hamlin, Dr. A. C., Bangor, Me. (10). 1874. C E H
Hanaman, C. E., Troy, N. Y. (19). 1883. F
Hardy, Prof. A. S., Dartmouth College, Hanover, N. H. (28). 1883. A
Harkness, Prof. William, U. S. N. Observatory, Washington, D. C. (26). 1878. A B C D
Harrington, H. H., College Station, Texas (35). 1889. C
Harris, Uriah R., Lieutenant U. S. N., U. S. S. Ranger, care of Navy Pay Office, San Francisco, Cal. (34). 1886. A
Harris, W. T., Lock Box 1, Concord, Mass. (27). 1887. H I
Hart, Edw., Ph.D., Easton, Pa. (33). 1885. C
Hasbrouck, Prof. I. E., 364 Carlton Ave., Brooklyn, N. Y. (23). 1874. D A I
Hastings, C. S., Sheffield Scientific School of Yale College, New Haven, Conn. (25). 1878. B
Haupt, Prof. Lewis M., University of Pennsylvania, Philadelphia, Pa. (32). 1885. I D E
Hay, Prof. O. P., Irvington, Ind. (37). 1889. E F
Haynes, Henry W., 239 Beacon St., Boston, Mass. (28). 1884. H
Heilprin, Prof. Angelo, Acad. Nat. Sciences, Philadelphia, Pa. (33). 1885. E F
Hendricks, J. E., Des Moines, Iowa (29). 1885. A
Henshaw, Henry W., Bureau of Ethnology, Washington, D. C. (24). 1877. H
Hering, Rudolph, Civil and Sanitary Engineer, 277 Pearl St., New York, N. Y. (33). 1885. D E I

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Herrick, Clarence L., 12 Mason St., Mt. Auburn, Cincinnati, Ohio (31). 1884. **F E**

Hervey, Rev. A. B., Pres. St. Lawrence Univ., Canton, N.Y. (22). 1879. **F**

Hicks, Prof. Lewis E., State University, Lincoln, Neb. (31). 1885. **E F**

Hilgard, Prof. E. W., University of California, Berkeley, Cal. (11). 1874. **C E B**

Hilgard, Prof. J. E., Washington, D. C. (4). 1874. **A**

Hill, Chas. S., care Dep't of State, Washington, D. C. (33). 1887. **A I**

Hill, Robert Thomas, Univ. of Texas, Austin, Texas (36). 1889. **E**

Himes, Prof. Charles F., Carlisle, Pa. (29). 1882. **B C**

Hirschfelder, Chas. A., Vice Consul U. S. A., Toronto, Ontario, Can. (33). 1887. **H**

Hitchcock, Prof. Charles H., Hanover, N. H. (11). 1874. **E**

Hitchcock, Romyn, Washington, D. C. (29). 1881. **C B**

Hobbs, A. C., Bridgeport, Conn. (28). 1886. **D**

Hodges, N. D. C., Editorial office of Science, 47 Lafayette St., New York, N. Y. (29). 1882. **B**

Hoffmann, Dr. Fred., "Rundschau," P. O. Box 1680, New York, N. Y. (28). 1881. **C F**

Holden, Prof. E. S., Lick Observatory, San José, Cal. (23). 1875. **A**

Holman, Silas W., Massachusetts Institute of Technology, Boston, Mass. (31). 1883. **B**

Holmes, Prof. Jos. A., Chapel Hill, N. C. (33). 1887. **E F**

Holmes, Dr. Oliver Wendell, 296 Beacon St., Boston, Mass. (29). 1881. **H**

Holmes, Wm. H., Bureau of Ethnology, Smithsonian Institution, Washington, D. C. (30). 1883. **H**

Horsford, Prof. E. N., Cambridge, Mass. (1). 1876. **C E**

Hosea, Lewis M., Johnston Building, Cincinnati, Ohio (30). 1883.

Hotchkiss, Major Jed., Staunton, Va. (31). 1883. **E H I**

Hough, Prof. G. W., Director Dearborn Observatory, Evanston, Ill. (15). 1874. **A**

Hovey, Rev. Horace C., 14 Park St., Bridgeport, Conn. (29). 1883. **E H**

Howard, Leland O., Dep't of Agric., Washington, D. C. (37). 1889. **F**

Howe, Jas. Lewis, Louisville, Ky. (36). 1888. **C**

Hoy, Philo R., M.D., 902 Main St., Racine, Wis. (17). 1875. **F H**

Hulst, Rev. Geo. D., 15 Himrod St., Brooklyn, N. Y. (29). 1887. **F**

Hunt, George, 119 Prospect St., Providence, R. I. (9). 1874.

Hunt, Dr. T. Sterry, Park Avenue Hotel, New York, N. Y. (1). 1874. **C E**

Hyatt, Prof. Alpheus, Natural History Society, Boston, Mass. (18). 1875. **E**

Hyde, Prof. E. W., Station D, Cincinnati, Ohio (25). 1881. **A**

Iddings, Joseph P., U. S. Geol. Survey, Washington, D. C. (31). 1884. **E**

Jacobus, David S., Stevens Institute, Hoboken, N. J. (36). 1889. **D B A**

James, Edmund J., Ph.D., Univ. of Pa., Philadelphia, Pa. (33). 1887. **I**

James, Jos. F., M.S., U. S. Geol. Survey, Washington, D. C. (30). 1882. **F E**

Jastrow, Dr. Jos., Johns Hopkins Univ., Baltimore, Md. (35). 1887. **H F**

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Jayne, Horace F., 1826 Chestnut St., Philadelphia, Pa. (29). 1884. **F H**
Jeffries, B. Joy, M.D., 15 Chestnut St., Boston, Mass. (29). 1881. **F H**
Jenkins, Edw. H., New Haven, Conn. (33). 1885. **C**
Jenks, Elisha T., Middleborough, Mass. (22). 1874. **D**
Jenks, Prof. J. W. P., Middleborough, Mass. (2). 1874. **B**
Jewell, Theo. F., Commander U. S. Navy, Naval Torpedo Station and War College, Newport, R. I. (25). 1882. **B**
Jillson, Dr. B. C., 342 River Ave., E.E., Pittsburgh, Pa. (14). 1881. **E H F**
Johnson, Lawrence C., U. S. Geol. Survey, Gainesville, Fla. (33). 1887.
Johnson, Otis C., Ann Arbor, Mich. (34). 1886. **C**
Johnson, Prof. W. W., Naval Academy, Annapolis, Md. (29). 1881. **A**
Jordan, Prof. David S., Pres. Indiana Univ., Bloomington, Ind. (31). 1883. **F**
Joy, Prof. Charles A., care F. Hoffmann, Stockbridge, Mass. (8). 1879.
Julien, A. A., New York Acad. of Sciences, New York, N. Y. (24). 1875. **E C**

Kedzie, Prof. Robert C., Agricultural College, Mich. (29). 1881. **C**
Keiser, Edward H., Ph.D., Prof. of Chemistry, Bryn Mawr College, Bryn Mawr, Montgomery Co., Pa. (35). 1888. **C**
Kellicott, David S., Columbus, Ohio (31). 1883. **F**
Kemp, James F., Cornell Univ., Ithaca, N. Y. (36). 1888. **E**
Kendall, Prof. E. Otis, 3826 Locust St., Philadelphia, Pa. (29). 1882. **A**
Kent, William, Passaic, N. J. (26). 1881. **D I**
Kershner, Prof. Jefferson E., Lancaster City, Pa. (29). 1883. **A B**
Kimball, Arthur Lalanne, Johns Hopkins Univ., Baltimore, Md. (33). 1885. **B**
Kinnicutt, Dr. Leonard P., Polytechnic Inst., Worcester, Mass. (28). 1883. **C**
Kirkwood, Prof. Daniel, Arlington Ave., Riverside, Cal. (7). 1874. **A**
Klotz, Otto Julius, Preston, Ontario, Can. (38). 1889.
Kunz, G. F., 402 Garden St., Hoboken, N. J. (29). 1883. **E H C**

Ladd, E. F., Geneva, N. Y. (36). 1889. **C**
Laflamme, Prof. J. C. K., Laval Univ., Quebec, Can. (29). 1887. **E B**
LaFlesche, Francis, Indian Bureau, Interior Dep't, Washington, D. C. (33). 1885. **H**
Lambert, Rev. Thomas R., D.D., Hotel Oxford, Huntington Ave., Boston, Mass. (18). 1874.
Landreth, Prof. Olin H., Vanderbilt Univ., Nashville, Tenn. (28). 1883. **D**
Langdon, Dr. F. W., 65 West 7th St., Cincinnati, Ohio (30). 1882. **F H**
Langley, Prof. J. W., 5914 Walnut St., E. End, Pittsburgh, Pa. (23). 1875. **C B**
Langley, Prof. S. P., Secretary Smithsonian Institution, Washington, D. C. (18). 1874. **A B**
Lanza, Prof. Gaetano, Mass. Institute of Technology, Boston, Mass. (29). 1882. **D A B**

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Larkin, Edgar L., Director Knox College Observatory, Galesburg, Ill. (28). 1883. **A**

Lattimore, Prof. S. A., University of Rochester, Rochester, N. Y. (15). 1874. **C**

Lawrence, George N., 45 E. 21st St., New York, N. Y. (7). 1877. **F**

Lazenby, Prof. Wm. R., Columbus, Ohio (30). 1882. **B I**

Leavenworth, Francis P., Haverford College P. O., Montgomery Co., Pa. (30). 1888. **A**

LeConte, Prof. Joseph, Univ. of Cal., Berkeley, Cal. (29). 1881. **E F**

Ledoux, Albert R., Ph.D., 39 W. 50th St., New York, N. Y. (26). 1881. **C**

Leeds, Prof. Albert R., Stevens Institute, Hoboken, N. J. (23). 1874. **C F**

Lehmann, G. W., Ph.D., 111 S. Gay St., Baltimore, Md. (30). 1885. **C B**

Lesley, Prof. J. Peter, State Geologist of Pennsylvania, 1008 Clinton St., Philadelphia, Pa. (2). 1874. **E**

Libbey, Prof. William, jr., Princeton, N. J. (29). 1887. **E F**

Lilly, Gen. Wm., Mauch Chunk, Carbon Co., Pa. (28). 1882. (Patron) **F E**

Lindsley, J. Berrien, M.D., 135 North Spruce St., Nashville, Tenn. (1). 1874. **F**

Lintner, J. A., N. Y. State Entomologist, Room 27, Capitol, Albany, N. Y. (22). 1874. **F**

Litton, Abram, 2220 Eugenia St., St. Louis, Mo. (28). 1879. **C**

Lloyd, Mrs. Rachel, Box 675, Lincoln, Neb. (31). 1889. **C**

Lockwood, Samuel, Ph.D., Freehold, Monmouth Co., N. J. (18). 1875. **F B A**

Lord, Prof. Nat. W., State Univ., Columbus, Ohio (29). 1881. **C**

Loudon, Prof. James, Toronto, Ontario, Can. (25). 1881. **B A**

Loughridge, Dr. R. H., South Carolina College, Columbia, S. C. (21). 1874. **E C**

Love, Edward G., School of Mines, Columbia College, New York, N. Y. (24). 1882. **C**

Lovering, Prof. Joseph, Harv. Univ., Cambridge, Mass. (2). 1875. **B A**

Lupton, Prof. N. T., Auburn, Ala. (17). 1874. **C**

Lyle, David Alexander, Captain Ordnance Dept. U. S. A., Ordnance Office, Washington, D. C. (28). 1880. **D**

Lyon, Dr. Henry, 34 Monument Sq., Charlestown, Mass. (18). 1874.

McAdams, Wm., Alton, Ill. (27). 1885. **E H**

McCauley, Capt. C. A. H., Ass't Q. M., U. S. A., 321 Michigan Ave., Chicago, Ill. (29). 1881.

McCreath, Andrew S., 228 Market St., Harrisburgh, Pa. (33). 1889. **C E**

McGee, W. J., U. S. Geol. Survey, Washington, D. C. (27). 1882. **E**

McGill, John T., Ph.D., Vanderbilt Univ., Nashville, Tenn. (36). 1888. **C**

McLeod, Prof. C. H., McGill Univ., Montreal, P. Q. Can. (35). 1887. **A B D**

McMurtrie, William, care New York Tartar Co., 63 William St., New York, N. Y. (22). 1874. **C**

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McNeill, Malcolm, Lake Forest, Ill. (32). 1885. **A**

Mabery, Prof. C. F., Case School of Applied Science, Cleveland, Ohio (29). 1881. **C**

Macfarlane, Prof. A., Univ. of Texas, Austin, Texas (34). 1886. **B A**

Mackintosh, James B., Consolidated Gas Co., 21st St. and Ave. A, New York, N. Y. (27). 1883. **C B**

Macloskie, Prof. George, College of New Jersey, Princeton, N. J. (25). 1882. **F**

Magie, Prof. William F., College of New Jersey, Princeton, N. J. (35). 1887.

Mallery, Col. Garrick, U. S. Army, Bureau of Ethnology, Washington, D. C. (26). 1879. **H**

MANN, B. PICKMAN, 1918 Sunderland Place, Washington, D. C. (22). 1874. **I F**

Marcy, Oliver, LL.D., Evanston, Ill. (10). 1874. **E**

Markoe, Prof. Geo. F. H., 29 Montrose St., Roxbury, Mass. (29). 1881.

MARSH, PROF. O. C., Yale College, New Haven, Conn. (15). 1874. **F H**

Martin, Prof. Daniel S., 236 West 4th St., New York, N. Y. (23). 1879. **E F**

Martin, Prof. H. Newell, Johns Hopkins University, Baltimore, Md. (27). 1880. **F H**

Martin, Miss Lillie J., Girls High School, San Francisco, Cal. (32). 1886. **F C**

Martin, Prof. Wm. J., Davidson College, N. C. (31). 1884. **C E**

Mason, Prof. Otis T., National Mus., Washington, D. C. (25). 1877. **H**

Mason, Dr. William P., Prof. Rensselaer Polytechnic Inst., Troy, N. Y. (31). 1886. **C**

Matthews, Washington, 1262 New Hampshire Ave., cor. 21st St., N. W., Washington, D. C. (37). 1888. **H**

Maxwell, Rev. Geo. M., Wyoming, Hamilton Co., Ohio (30). 1886. **H E**

Mayer, Prof. A. M., South Orange, N. J. (19). 1874.

Meehan, Thomas, Germantown, Pa. (17). 1875. **F**

Mees, Prof. Carl Leo, Columbus, Ohio (24). 1876. **B C**

Mendenhall, Prof. T. C., U. S. C. and G. Survey, Washington, D. C. (20). 1874. **B**

Menocal, Aniclto G., C.E., U. S. N., Navy Yard, Washington, D. C. (36). 1888. **D**

Merriam, C. Hart, M.D., Smith. Inst., Washington, D. C. (33). 1885. **F**

Merrill, Frederick J. H., Ph.B., 126 E. 60th St., New York, N. Y. (35). 1887. **E**

Merriman, C. C., 1910 Surf St., Lake View, Chicago, Ill. (29). 1880. **F**

Merriman, Prof. Mansfield, Lehigh University, Bethlehem, Pa. (32). 1885. **A D**

Metz, Charles L., M.D., Madisonville, Hamilton Co., Ohio (30). 1885. **H**

Michael, Mrs. Helen Abbott, 1509 Locust St., Philadelphia, Pa. (33). 1885. **C F**

Michelson, A. A., Master U. S. N., 7 Rockwell St., Cleveland, Ohio (26). 1879. **B**

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Mills, T. Wesley, Montreal, P. Q., Can. (31). 1886. F H
Minot, Dr. Charles Sedgwick, 25 Mt. Vernon St., Boston, Mass. (28). 1880. F
Minot, Francis, M.D., 65 Marlborough St., Boston, Mass. (29). 1884.
Mixter, Prof. Wm. G., New Haven, Conn. (30). 1882. C
Moore, Prof. J. W., M.D., Lafayette College, Easton, Pa. (22). 1874. B D A
Moore, Robert, C.E., 61 Vanderventer Place, St. Louis, Mo. (33). 1887. D B I
Morgan, Frank H., Cornell Univ., Ithaca, N. Y. (35). 1889. C
Morley, Prof. Edward W., 749 Republic St., Cleveland, Ohio (18). 1876. C B E
Morong, Rev. Thomas, Ashland, Mass. (35). 1887. F
Morris, Rev. John G., Baltimore, Md. (12). 1874.
Morse, Prof. E. S., Salem, Mass. (18). 1874. F H
Morton, H., Stevens Institute Technology, Hoboken, N. J. (18). 1875. B C
Moser, Lieut. Jeff. F., U. S. N., Coast Survey Office, Washington, D. C. (28). 1889. E
Moses, Prof. Thos. F., Urbana Univ., Urbana, Ohio (25). 1883. H F
Munroe, Prof. C. E., Chemist to Bureau of Ordnance, U. S. Torpedo Station, Newport, R. I. (22). 1874. C
Murdoch, John, Smithsonian Institution, Washington, D. C. (29). 1886. F H
Murdock, J. B., Lieut. U. S. N., 24 Alaska St., Roxbury, Mass. (28). 1885. B
Murtfeldt, Miss Mary E., Kirkwood, Mo. (27). 1881. F
Myers, John A., Agric. Exper. Station, Morgantown, W. Va. (30). 1889. C

Nason, Frank L., 5 Union St., New Brunswick, N. J. (36). 1888. E
Nason, Prof. H. B., Rensselaer Polytechnic Institute, Troy, N. Y. (13). 1874. C E
Nelson, Prof. A. B., Centre College, Danville, Ky. (30). 1882. A B D
Newberry, Prof. J. S., Columbia College, New York, N. Y. (5). 1875. E F H I
Newberry, Prof. Spencer Baird, Ithaca, N. Y. (33). 1887. C
Newcomb, Prof. S., Navy Dep't, Washington, D. C. (13). 1874. A B
Newton, Hubert A., New Haven, Conn. (6). 1874. A
Nichols, E. L., Ph.D., Cornell Univ., Ithaca, N. Y. (28). 1881. B C
Nicholson, Prof. H. H., Box 675, Lincoln, Neb. (36). 1888.
Niles, Prof. W. H., Cambridge, Mass. (16). 1874.
Nipher, Prof. F. E., Washington Univ., St. Louis, Mo. (24). 1876. B
Norton, Lewis M., Ph.D., Mass. Institute of Technology, Boston, Mass. (29). 1884. C
Norton, Prof. Thomas H., Univ. of Cincinnati, Cincinnati, Ohio (35). 1887. C
Novy, Frederick George, Ann Arbor, Mich. (36). 1889.

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Noyes, Prof. Wm. A., Rose Polytechnic Inst., Terre Haute, Ind. (32). 1885. C

Nuttall, Mrs. Zella, care Peabody Museum, Cambridge, Mass. (35). 1887. H

Oliver, Charles A., M.D., 1507 Locust St., Philadelphia, Pa. (33). 1886. F H B

Oliver, Prof. James E., P. O. Box 1566, Ithaca, N. Y. (7). 1875. A B I

Ordway, Prof. John M., Tulane University, New Orleans, La. (9). 1875. C

Orton, Prof. Edward, President Ohio Agricultural and Mechanical College, Columbus, Ohio (19). 1875. E

Osborn, Henry F., S.D., Princeton, N. J. (29). 1888.

Osborn, Henry Leslie, 3 East 47th St., Hamline, Minn. (29). 1887.

Osborn, Herbert, Ames, Iowa (32). 1884. F

Osborne, J. W., 212 Delaware Ave. N. E., Washington, D. C. (22). 1874. D C B

Osmond, Prof. I. Thornton, State College, Centre Co., Pa. (33). 1889. B A C

Packard, Dr. A. S., 115 Angell St., Providence, R. I. (16). 1875. F E

Paine, Cyrus F., 305 Ellwanger & Barry Building, Rochester, N. Y. (12). 1874. B A

Paine, Nathaniel, Worcester, Mass. (18). 1874. H

Palfray, Hon. Charles W., Salem, Mass. (21). 1874.

Palmer, Chase, Ph.D., Wabash College, Crawfordsville, Ind. (33). 1889. C

Parke, John G., Gen. U. S. A., 16 Lafayette Square, Washington, D. C. (29). 1881. D

Parkhurst, Henry M., Law Stenographer, 25 Chambers St., New York, N. Y. (23). 1874. A

Paul, Prof. Henry M., U. S. Naval Observatory, Washington, D. C. (33). 1885. A B

Peabody, Cecil H., Ass't Prof. Steam Eng., Mass. Institute Technology, Boston, Mass. (32). 1887. D

Peabody, Selim H., Regent University of Illinois, Champaign, Ill. (17). 1885. D B F

Peckham, S. F., 159 Olney St., Providence, R. I. (18). 1875. C B E

Pedrick, Wm. R., Lawrence, Mass. (22). 1875.

Peet, Rev. Stephen D., Mendon, Ill. (24). 1881. H

Peirce, Benj. O., jr., Ass't Prof., Harvard College, Cambridge, Mass. (29). 1886. A B

Pengra, Charles P., M.D., 130 Dartmouth St., Boston, Mass. (34). 1887. F C

Perkins, Prof. George H., Burlington, Vt. (17). 1882. H F E

Peter, Dr. Robert, Kentucky Geol. Survey, Lexington, Ky. (29). 1881. C

Peters, Edw. T., P. O. Box 265, Washington, D. C. (33). 1889. I

Pettee, Prof. William H., Ann Arbor, Mich. (24). 1875. E

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Phillips, A. W., New Haven, Conn. (24). 1879.
Phillips, Prof. Francis C., Western Univ., Allegheny, Pa. (36). 1889. C
Phillips, Henry, jr., 320 So. 11th St., Philadelphia, Pa. (32). 1887. H I
Phippen, Geo. D., Salem, Mass. (18). 1874. F
Pickering, Prof. E. C., Director of Observatory, Cambridge, Mass. (18). 1875. A B
Pickering, William H., Harvard Observatory, Cambridge, Mass. (29). 1883. B A
Pilling, James C., Box 591, Washington, D. C. (28). 1882. F H I
Pillsbury, Prof. John H., Smith College, Northampton, Mass. (23). 1885. F H
Platt, Franklin, Ass't Geologist, 2nd Geol. Survey of Pa., 615 Walnut St., Philadelphia, Pa. (27). 1882. E
Pohlman, Dr. Julius, Buffalo, N. Y. (32). 1884. E F
Porter, Thos. C., LL.D., Lafayette College, Easton, Pa. (33). 1887. F
Potter, William B., Washington Univ., St. Louis, Mo. (25). 1879.
Powell, Major J. W., U. S. Geologist, 910 M St. N. W., Washington, D. C. (23). 1875. E H
Power, Prof. Frederick B., Univ. of Wis., Madison, Wis. (31). 1887. C
Prentiss, Prof. A. N., Cornell Univ., Ithaca, N. Y. (35). 1887. F
Prentiss, D. Webster, M.D., 1101 14th St. N. W., Washington, D. C. (29). 1882. F
Prescott, Prof. Albert B., Ann Arbor, Mich. (23). 1875. C
Preston, E. D., Ass't U. S. Coast and Geodetic Survey, Washington, D. C. (37). 1889. A E
Pritchett, Henry S., Director Observatory Washington University, St. Louis, Mo. (29). 1881. A
Procter, John R., Dir. Kentucky Geol. Surv., Frankfort, Ky. (26). 1881.
Pulsifer, Wm. H., 1837 Kennett Place, St. Louis, Mo. (26). 1879. A H
Pumpelly, Prof. Raphael, U. S. Geological Survey, Newport, R. I. (17). 1875. E I
Putnam, Prof. F. W., Curator Peabody Museum American Archæology and Ethnology, Cambridge, Mass. (Address as Permanent Secretary A. A. A. S., Salem, Mass.) (10). 1874. H
Pynchon, Rev. T. R., Trinity Coll., Hartford, Conn. (23). 1875.

Quincy, Edmund, 88 Clinton St., Boston, Mass. (11). 1874.

Rauch, Dr. John H., Springfield, Ill. (11). 1875.
Raymond, Rossiter W., 17 Burling Slip, New York, N. Y. (15). 1875. E I
Redfield, J. H., 216 W. Logan Square, Philadelphia, Pa. (1). 1874. F
Reed, E. Baynes, London, Ontario, Can. (27). 1882.
Rees, Prof. John K., Columbia College, New York, N. Y. (26). 1878. A E B
Remsen, Prof. Ira, Johns Hopkins Univ., Baltimore, Md. (22). 1875. C
Rice, John M., U. S. Naval Academy, Annapolis, Md. (25). 1881. A D

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Rice, Prof. Wm. North, Wesleyan University, Middletown, Conn. (18). 1874. **E F**

Richards, Prof. Charles B., 313 York St., New Haven, Conn. (33). 1885. **D**

Richards, Edgar, Office of Internal Revenue, Treasury Dept., Washington, D. C. (31). 1886. **C**

Richards, Prof. Robert H., Mass. Inst. Tech., Boston, Mass. (22). 1875 **D**

Richards, Mrs. Robert H., Prof. Mass. Inst. of Tech., Boston, Mass. (23). 1878. **C**

Richardson, Clifford, Dep't of Agric., Washington, D. C. (30). 1884. **C**

Ricketts, Prof. Palmer C., 17 1st St., Troy, N. Y. (33). 1887. **D A**

Ricketts, Prof. Pierre de Peyster, School of Mines, Columbia College, New York, N. Y. (26). 1880. **C D E**

Riley, Prof. C. V., U. S. Entomologist, 1700 13th St. N. W., Washington, D. C. (17). 1874. **F H I**

Ritchie, E. S., Newton Highlands, Mass. (10). 1877. **B**

Roberts, Prof. Isaac P., Ithaca, N. Y. (33). 1886. **I**

Robinson, Prof. Franklin C., Brunswick, Me. (29). 1889. **C D**

Robinson, Prof. S. W., Univ. of Ohio, Columbus, Ohio (30). 1883. **D B A**

Rockwell, Gen. Alfred P., Manchester, Mass. (10). 1882. **E**

Rockwell, Chas. H., Box 293, Tarrytown, N. Y. (28). 1883. **A D**

Rockwood, Prof. Charles G., jr., College of New Jersey, Princeton, N. J. (20). 1874. **A E B D**

Rogers, Fairman, Messrs. Dick Bros. & Co., No. 134 S. Fourth St., Philadelphia, Pa. (11). 1874.

Rogers, Prof. W. A., Colby Univ., Waterville, Me. (15). 1875. **A B D**

Rominger, Dr. Carl, Ann Arbor, Mich. (21). 1879. **E**

Rood, Prof. O. N., Columbia College, New York, N. Y. (14). 1875. **B**

Ross, Waldo O., 31 Otis St., Boston, Mass. (29). 1882.

Rowland, Prof. Henry A., Baltimore, Md. (29). 1880.

Runkle, Prof. J. D., Mass. Institute of Technology, Boston, Mass. (2). 1875. **A D**

Russell, I. C., U. S. Geological Survey, Washington, D. C. (25). 1882.

Rutherford, Lewis M., 175 Second Ave., New York, N. Y. (13). 1875.

Sadtler, Prof. Sam'l P., Univ. of Pa., Philadelphia, Pa. (22). 1875. **C**

Safford, Dr. James M., Nashville, Tenn. (6). 1875. **E C F**

Salmon, Daniel E., Dep't of Agric., Washington, D. C. (31). 1885. **F**

Sampson, Commander W. T., U. S. N., Naval Acad., Annapolis, Md. (25). 1881. **B A**

Sanborn, Rev. John W., Lockport, N. Y. (33). 1886. **H**

Saunders, William, Director Agricultural Experiment Station, Ottawa, Ontario, Can. (17). 1874. **F**

Schaeberle, J. M., Astronomer in the Lick Observatory, San José, Cal. (34). 1886. **A**

Schanck, Prof. J. Stillwell, Princeton, New Jersey (4). 1882. **C B H**

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Schott, Charles A., U. S. Coast and Geodetic Survey Office, Washington, D. C. (8). 1874. **A**

Schweinitz, Dr. E. A. v., Dept. of Agric., Washington, D.C. (36). 1889. **C**

Schweitzer, Prof. Paul, State University of Missouri, Columbia, Mo. (24). 1877. **C B**

Scott, Prof. Wm. B., Princeton, N. J. (33). 1887. **F E**

Scovell, M. A., Director Kentucky Agricultural Experiment Station, Lexington, Ky. (35). 1887.

Scribner, F. Lamson, U. S. Dep't of Agric., Washington, D. C. (34). 1887. **F**

SCUDDER, SAMUEL H., Cambridge, Mass. (13). 1874. **F**

Seaman, W. H., Chemist, 1424 11th St. N. W., Washington, D. C. (23). 1874. **C F**

See, Horace, 1 Broadway, New York, N. Y. (34). 1886. **D**

Seiler, Carl, M.D., 1346 Spruce St., Philadelphia, Pa. (29). 1882. **F B**

Seymour, William P., M.D., 105 Third St., Troy, N. Y. (19). 1888. **H**

Sharples, Stephen P., 13 Broad St., Boston, Mass. (29). 1884. **C**

Sharpless, Prof. Isaac, Haverford College, Pa. (33). 1888. **A**

Sheafer, P. W., Pottsville, Pa. (4). 1879. **E**

Shimer, Porter W., E.M., Easton, Pa. (38). 1889. **C**

Shutt, Frank T., M.A., F.E.C., F.C. S., Chemist to the Dominion Experimental Farms, Ottawa, Ontario, Can. (38). 1889.

Sias, Solomon, M.D., Schoharie, Schoharie Co., N. Y. (10). 1874.

Sigsbee, Chas. D., Comd'r U. S. N., U. S. Naval Acad., Annapolis, Md. (28). 1882. **D E**

Silliman, Prof. Justus M., Lafayette Coll., Easton, Pa. (19). 1874. **D E**

Simonds, Prof. Frederic W., Univ. of Texas, Austin, Texas. (25). 1888. **E F**

Skinner, Joseph J., Massachusetts Inst. Technology, Boston, Mass. (23). 1880. **B**

Smiley, Charles W., U. S. Fish Commission, Washington, D. C. (28). 1883. **I**

Smith, Prof. Chas. J., 35 Adelbert St., Cleveland, Ohio (32). 1885. **A B**

Smith, Edwin, Ass't U. S. Coast and Geodetic Survey, Washington, D. C. (30). 1882. **A B**

Smith, Prof. Erastus G., Beloit College, Beloit, Wis. (34). 1887. **C**

Smith, Prof. Eugene A., University, Ala. (20). 1877. **E C**

Smith, Prof. Francis H., University of Virginia, Charlottesville, Va. (26). 1880. **B A**

Smith, John B., Professor of Entomology, Rutgers College, New Brunswick, N. J. (32). 1884. **F**

SMITH, QUINTIUS C., M.D., No. 617 Colo. St., Austin, Texas (26). 1881. **F**

Smith, Prof. S. I., Yale College, New Haven, Conn. (18). 1875. **F**

Smith, Dr. Theobald, Bureau of Animal Industry, U. S. Dep't of Agric., Washington, D. C. (35). 1887. **F**

Smock, Prof. John Conover, New York State Museum, Albany, N. Y. (23). 1879. **E**

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Snow, Prof. F. H., Lawrence, Kan. (29). 1881. **F E**
Snow, Benj. W., Cornell Univ., Ithaca, N. Y. (35). 1889. **B**
Snyder, Henry, B.Sc., Miami Univ., Oxford, Ohio (30). 1888. **B C**
Snyder, Prof. Monroe B., High School Observatory, Philadelphia, Pa. (24). 1882. **A B**
Soule, R. H., Gen. Agent, The Union Switch & Signal Co., Pittsburgh, Pa. (33). 1886. **D**
Spalding, Volney M., Ann Arbor, Mich. (34). 1886. **F**
Spencer, Guilford L., Dept. Agric., Washington, D. C. (36). 1889. **C D**
Spencer, Prof. J. William, Prof. of Geology, University of Georgia, Athens, Ga. (28). 1882. **E**
Springer, Dr. Alfred, Box 621, Cincinnati, Ohio (24). 1880. **C**
Staley, Cady, LL.D., Pres. Case School of Applied Sciences, Cleveland, Ohio (37). 1888. **D**
Stearns, R. E. C., care Smithsonian Institution, Washington, D. C. (18). 1874. **F**
Steiner, Dr. Lewis H., Enoch Pratt Free Library, Baltimore, Md. (7). 1874. **I**
Stephens, W. Hudson, Lowville, N. Y. (18). 1874. **E H**
Sternberg, George M., Major and Surgeon U. S. A., Johns Hopkins Univ., Baltimore, Md. (24). 1880. **F**
Stevens, W. LeConte, 170 Joralemon St., Brooklyn, N. Y. (29). 1882. **B A C**
Stevenson, Prof. John J., Univ. of New York, New York, N. Y. (36). 1888.
Stockwell, John N., 1008 Case Avenue, Cleveland, Ohio (18). 1875. **A**
Stoddard, Prof. John T., Smith Coll., Northampton, Mass. (35). 1889. **B C**
Stone, George H., Colorado Springs, Col. (29). 1882. **E F**
Stone, Mrs. Leander, Pres. Y. W. C. A., 3352 Indiana Avenue, Chicago, Ill. (22). 1874. **F E**
Stone, Ormond, Director Leander McCormick Observatory, University of Virginia, Va. (24). 1876. **A**
Story, Wm. E., Johns Hopkins Univ., Baltimore, Md. (29). 1881. **A**
Stowell, Prof. T. B., Potsdam, N. Y. (28). 1885. **F**
Stringham, Prof. Irving, Univ. of Cal., Berkeley, Cal. (33). 1885. **A**
Stuart, Prof. A. P. S., Lincoln, Nebraska (21). 1874. **C**
Sturtevant, E. Lewis, M.D., Geneva, N. Y. (29). 1882. **F**
Swift, Lewis, Ph.D., Rochester, N. Y. (29). 1882. **A**

Tainter, Charles Sumner, "The Gerlach," 55 W. 27th St., New York, N. Y. (29). 1881. **B D A**
Taylor, H. C., Commander U. S. N., Poughkeepsie, N. Y. (30). 1889.
Taylor, Thos., M.D., Dep't of Agric., Washington, D. C. (29). 1885. **F C**
Taylor, William B., Smithsonian Institution, Washington, D. C. (29). 1881. **B A**
Terry, Prof. N. M., U. S. Naval Academy, Annapolis, Md. (23). 1874. **B**
Thomas, Benj. F., Ph.D., State Univ., Columbus, Ohio (29). 1882. **B A**
Thomson, Elihu, Thomson-Houston Electric Co., Lynn, Mass. (37). 1888. **B**

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Thomson, Wm., M.D., 1426 Walnut St., Philadelphia, Pa. (33). 1885. **B**
Thurston, Prof. R. H., Sibley College, Cornell University, Ithaca, N. Y. (23). 1875. **D**
Tittmann, Otto H., U. S. Coast and Geodetic Survey Office, Washington, D. C. (24). 1888. **A**
Todd, Prof. David P., Director Lawrence Observatory, Amherst College, Amherst, Mass. (27). 1881. **A B D**
Todd, Prof. James E., Tabor, Fremont Co., Iowa (22). 1886. **E F**
Towne, Henry R., Pres. Yale and Towne Manufacturing Co., Stamford, Conn. (33). 1888. **D B**
Townshend, Prof. N. S., Ohio State Univ., Columbus, Ohio (17). 1881. **F H**
Tracy, Sam'l M., Agricultural College, Miss. (27). 1881. **F**
Traphagen, Frank W., Ph.D., Prof. of Chemistry, The College of Montana, Deer Lodge City, Montana (35). 1889. **C F E**
Trembley, J. B., M.D., 952 8th St., Oakland, Alameda Co., Cal. (17). 1880. **B F**
Trimble, Prof. Henry, 145 No. 10 St., Philadelphia, Pa. (34). 1889. **C**
Trowbridge, Prof. W. P., School of Mines, Columbia College, New York, N. Y. (10). 1874. **D**
True, Fred W., U. S. National Museum, Washington, D. C. (28). 1882. **F**
Trumbull, Dr. J. Hammond, Hartford, Conn. (29). 1882. **H**
Tucker, Willis G., M.D., Albany Med. Coll., Albany, N. Y. (29). 1888. **C**
Tuttle, Prof. Albert H., Univ. of Virginia, Va. (17). 1874. **F**

Uhler, Philip R., 218 W. Hoffman St., Baltimore, Md. (19). 1874. **F E**
Underwood, Prof. Lucien M., cor. Comstock Ave. and Marshall St., Syracuse, N. Y. (33). 1885. **F**
Upham, Warren, 21 Newbury St., Somerville, Mass. (25). 1880. **E**
Upton, Winslow, Brown Univ., Providence, R. I. (29). 1883. **A**

Van der Weyde, P. H., M.D., 236 Duffield St., Brooklyn, N. Y. (17). 1874. **B**
Van Dyck, Prof. Francis Cuyler, New Brunswick, N. J. (28). 1882. **B C F**
Van Vleck, Prof. John M., Middletown, Conn. (23). 1875. **A**
Vasey, George, M.D., Dep't of Agric., Washington, D. C. (32). 1889. **F**
Vaughn, Dr. Victor C., Ann Arbor, Mich. (34). 1887. **C**
Very, Samuel W., Lieut. Comdr. U. S. N., U. S. S. Santee, Naval Acad., Annapolis, Md. (28). 1886. **A B**
Vining, Edward P., N. Y. & N. E. R. R. Co., 246 Federal St., Boston, Mass. (32). 1887. **H**
Vogdes, A. W., 1st Lt. 5th Art'y U. S. A., The Military Service Inst., Governor's Island, N. Y. (32). 1885. **E F**

Wachsmuth, Charles, 111 Marietta St., Burlington, Iowa (30). 1884. **E F**
Wadsworth, Prof. M. Edward, Ph.D., Director of the Michigan Mining School, State Geologist of Michigan, Houghton, Mich. (23). 1874. **E**
Walcott, Charles D., U. S. Geological Survey, Washington, D. C. (25). 1882. **E F**

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Waldo, Prof. Clarence, A., Rose Polytechnic Inst., Terre Haute, Ind. (37) 1889. **A**

Waldo, Leonard, S.D., Lockport, N. Y. (28). 1880. **A**

Wallace, Wm., Ansonia, Conn. (28). 1882.

Waller, E., School of Mines, Columbia College, New York, N. Y. (23). 1874.

Walmsley, W. H., 1016 Chestnut St., Philadelphia, Pa. (28). 1883. **F**

Ward, Prof. Henry A., Rochester, N. Y. (13). 1875. **F E H**

Ward, Lester F., U. S. Geological Survey, Washington, D. C. (26). 1879. **E F**

Ward, Dr. R. H., 53 Fourth St., Troy, N. Y. (17). 1874. **F B**

Ward, Wm. E., Port Chester, N. Y. (36). 1889. **D**

Warder, Prof. Robert B., Howard Univ., Washington, D. C. (19). 1881. **C B**

Warner, James D., 199 Baltic St., Brooklyn, N. Y. (18). 1874. **A B**

Warner, Worcester R., 887 Case Ave., Cleveland, Ohio (33). 1888. **A B D**

Warren, Cyrus M., Brookline, Mass. (29). 1882. **C**

Warren, Dr. Joseph W., Harvard Med. School, Boston, Mass. (31). 1886. **F**

Warren, Prof. S. Edward, Newton, Mass. (17). 1875. **A—I**

Watson, Sereno, Botanic Gardens, Cambridge, Mass. (22). 1875. **F**

Watson, Prof. Wm., 107 Marlborough St., Boston, Mass. (12). 1884. **A**

Webb, Prof. J. Burkitt, Stevens Inst., Hoboken, N. J. (31). 1883. **D B A**

Weber, Prof. Henry A., Ohio State Univ., Columbus, Ohio. (35). 1888. **F**

Webster, Prof. N. B., Grove House, Vineland, N. J. (7). 1874. **B C E**

Wells, Daniel H., Hartford, Conn. (18). 1875. **A I**

Westcott, O. S., Maywood, Cook Co., Ill. (21). 1874. **H F A**

Weston, Edward, 645 High St., Newark, N. J. (33). 1887. **B C D**

Wheatland, Dr. Henry, President Essex Inst., Salem, Mass. (1). 1874.

Wheeler, Prof. C. Gilbert, 81 Clark St., Chicago, Ill. (18). 1883. **C E**

Wheeler, Orlando B., Office Mo. River Com., 1515 Lucas Place, St. Louis, Mo. (24). 1882. **A D**

Wheildon, W. W., Box 229, Concord, Mass. (13). 1874. **B E**

White, Prof. C. A., Le Droit Park, Washington, D. C. (17). 1875. **E F**

White, Prof. H. C., Univ. of Georgia, Athens, Ga. (29). 1885. **C**

White, Prof. I. C., Univ. of W. Va., Morgantown, W. Va. (25). 1882. **E**

Whiteaves, J. F., Geol. Survey, Ottawa, Ontario, Can. (31). 1887. **E F**

Whitfield, R. P., American Museum Natural History, 77th St. & 8th Avenue, New York, N. Y. (18). 1874. **E F H**

Whiting, Miss Sarah F., Wellesley College, Wellesley, Mass. (31). 1883. **B A**

Whitman, Prof. Frank P., Adelbert College, Cleveland, Ohio (33). 1885.

Wilbur, A. B., Middletown, N. Y. (23). 1874.

Wilder, Prof. Burt G., Cornell University, Ithaca, N. Y. (22). 1875. **F**

Wiley, Prof. Harvey W., Dep't of Agric., Washington, D.C. (21). 1874. **C**

Williams, Benezette, 171 La Salle St., Chicago, Ill. (33). 1887. **D**

Williams, Charles H., M.D., C. B. and Q. Gen. Office, Chicago, Ill. (22). 1874.

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Williams, Geo. Huntington, Johns Hopkins Univ., Baltimore, Md. (33). 1886. E

Williams, Henry Shaler, Cornell Univ., Ithaca, N. Y. (18). 1882. E F

Williams, Prof. Henry W., 15 Arlington St., Boston, Mass. (11). 1874. H F

Williams, Prof. S. G., Cornell Univ., Ithaca, N. Y. (33). 1885. E

Willson, Prof. Frederick N., Princeton, N. J. (33). 1887. A D

Wilson, Sir Daniel, President University College, 117 Bloor St., Toronto, Ontario, Canada (25). 1876. H E

Wilson, Joseph M., Room 1036, Drexel Building, Philadelphia, Pa. (33). 1886. D

Wilson, Thomas, U. S. Nat'l Museum, Washington, D. C. (36). 1888. H.

Wilson, William Powell, 640 No. 32nd St., Philadelphia, Pa. (38). 1889. F

Winchell, Prof. Alex., Ann Arbor, Mich. (8). 1875. E

Winchell, Prof. N. H., Univ. of Minnesota, Minneapolis, Minn. (19). 1874. E H

Winlock, Wm. C., Smithsonian Institution, Washington, D. C. (33). 1885. A B

Winslow, Arthur, State Geologist, Jefferson City, Mo. (37). 1889. E

Wood, Prof. De Volson, Hoboken, N. J. (29). 1881.

Woodbury, C. J. H., 31 Milk St., Boston, Mass. (29). 1884. D

Woodward, Prof. Calvin M., 1761 Missouri Ave., St. Louis, Mo. (32). 1884. D A I

Woodward, R. S., care of U. S. Geol. Survey, Washington, D. C. (33). 1885. A B D

Wormley, T. G., Univ. of Pennsylvania, Philadelphia, Pa. (20). 1878.

Worthen, W. E., 63 Bleeker St., New York, N. Y. (36). 1888. D

Wrampelmeier, Theo. J., San Diego, Cal. (34). 1887. C

Wright, Prof. Albert A., Oberlin College, Oberlin, Ohio (24). 1880. E F

Wright, Prof. Arthur W., Yale Coll., New Haven, Conn. (14). 1874. A B

Wright, Rev. Geo. F., Oberlin College, Oberlin, Ohio (29). 1882. E

Wright, Prof. Thos. W., Union College, Schenectady, N. Y. (36). 1889.

Würtele, Rev. Louis C., Acton Vale, P. Q., Can. (11). 1875. E

Youmans, Wm. Jay, M.D., Popular Science Monthly, 1–5 Bond St., New York, N. Y. (28). 1889. F C

Young, A. V. E., Northwestern Univ., Evanston, Ill. (33). 1886. C B

Young, C. A., Prof. of Astronomy, College of New Jersey, Princeton, N. J. (18). 1874. A B D

[724 FELLOWS.]

SUMMARY.—PATRONS, 3; MEMBERS, 1229; HONORARY FELLOW, 1; FELLOWS, 723.

JUNE 18, 1890, TOTAL NUMBER OF MEMBERS OF THE ASSOCIATION, 1956.

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DECEASED MEMBERS.

[Unless by special vote of the Council, the names of those only who are members of the Association at the *time of their decease* will be included in this list. Information of the date and place of birth and death, to fill blanks in this list, is requested by the Permanent Secretary.]

Abbe, George W., New York, N. Y. (23). Died Sept. 25, 1879.

Abert, John James, Washington, D. C. (1). Born in Shepherdstown, Va., Sept. 17, 1788. Died in Washington, D. C., Sept. 27, 1863.

Adams, Charles Baker, Amherst, Mass. (1). Born in Dorchester, Mass., Jan. 11, 1814. Died in St. Thomas, W. I., Jan. 19, 1853.

Adams, Edwin F., Charlestown, Mass. (18).

Adams, Samuel, Jacksonville, Ill. (18). Born Dec. 19, 1806. Died April 29, 1877.

Agassiz, Louis, Cambridge, Mass. (1). Born in Parish of Motier, Switzerland, May 28, 1807. Died in Cambridge, Mass., Dec. 14, 1873.

Ainsworth, J. G., Barry, Mass. (14).

Alexander, Stephen, Princeton, N. J. (1). Born Sept. 1, 1806. Died June 25, 1883.

Allen, Thomas, St. Louis, Mo. (27). Died April 8, 1882.

Allen, Zachariah, Providence, R. I. (1). Born in Providence, R. I., Sept. 15, 1795. Died March 17, 1882.

Allston, Robert Francis Withers, Georgetown, S. C. (3). Born in All Saints Parish, S. C., April 21, 1801. Died near Georgetown, S. C., April 7, 1864.

Alvord, Benjamin, Washington, D. C. (17). Born in Rutland, Vt., Aug. 18, 1813. Died Oct. 16, 1884.

Ames, M. P., Springfield, Mass. (1). Born in 1803. Died April 23, 1847.

Andrews, Ebenezer Baldwin, Lancaster, Ohio (7). Born in Danbury, Conn., April 29, 1821. Died in Lancaster, Ohio, Aug. 14, 1880.

Anthony, Charles H., Albany, N. Y. (6). Died in 1874.

Appleton, Nathan, Boston, Mass. (1). Born in New Ipswich, N. H., Oct. 6, 1779. Died July 14, 1861.

Armstrong, John W., Fredonia, N. Y. (24).

Ashburner, Wm., San Francisco, Cal. (29). Born in Stockbridge, Mass., March, 1831. Died in San Francisco, Cal., April 20, 1887.

Atwater, Mrs. S. T., Chicago, Ill. (17). Born Aug. 8, 1812. Died April 11, 1878.

Aufrecht, Louis, Cincinnati, Ohio (30).

Bache, Alexander Dallas, Washington, D. C. (1). Born in Philadelphia, Pa., July 19, 1806. Died at Newport, R. I., Feb. 17, 1867.

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Bache, Franklin, Philadelphia, Pa. (1). Born in Philadelphia, Pa., Oct. 25, 1792. Died March 19, 1864.

Bailey, Jacob Whitman, West Point, N. Y. (1). Born in Auburn, Mass., April 29, 1811. Died in West Point, N. Y., Feb. 26, 1857.

Baird, Spencer Fullerton, Washington, D. C. (1). Born in Reading, Pa., Feb. 3, 1823. Died in Wood's Holl, Mass., Aug. 19, 1887.

Bardwell, F. W., Lawrence, Kan. (13). Died in 1878.

Barnard, F. A. P., New York, N. Y. (7). Born in Sheffield, Mass., May 5, 1809. Died in New York, April 27, 1889.

Barnard, John Gross, New York, N. Y. (14). Born in Sheffield, Mass., May 19, 1815. Died in Detroit, Mich., May 14, 1882.

Barrett, Dwight H., Baltimore, Md. (36). Died in March, 1889.

Barrett, Moses, Milwaukee, Wis. (21). Died in 1873.

Barry, Redmond, Melbourne, Australia (25).

Bassett, Daniel A., Los Angeles, Cal. (29). Born Dec. 8, 1819. Died May 26, 1887.

Bassnett, Thomas, Jacksonville, Fla. (8). Born 1807. Died in Jacksonville, Fla., Feb. 16, 1886.

Bayne, Herbert Andrew, Kingston, Ont., Can. (29). Born in London, derry, Nova Scotia, Aug. 16, 1846. Died in Pictou, Can., Sept. 16, 1886.

Beach, J. Watson, Hartford, Conn. (23). Born Dec. 28, 1823. Died Mar. 16, 1887.

Beck, C. F., Philadelphia, Pa. (1).

Beck, Lewis Caleb, New Brunswick, N. J. (1). Born in Schenectady, N. Y., Oct. 4, 1798. Died April 20, 1853.

Beck, Theodoric Romeyn, Albany, N. Y. (1). Born in Schenectady, N. Y., Aug. 11, 1791. Died in Utica, N. Y., Nov. 19, 1855.

Beckwith, Henry C., Coleman's Station, N. Y. (29). Died July 12, 1885.

Belfrage, G. W., Clifton, Texas (29). Died Dec. 7, 1882.

Belknap, William B., Louisville, Ky. (29).

Bell, Samuel N., Manchester, N. H. (7). Born in Chester, N. H., March 25, 1829. Died in Manchester, N. H., Feb. 8, 1889.

Belt, Thomas, London, Eng. (27). Died Sept. 8, 1878.

Benedict, George Wyllys, Burlington, Vt. (16). Born Jan. 11, 1796. Died Sept. 23, 1871.

Bicknell, Edwin, Boston, Mass. (18). Born in 1830. Died March 19, 1877.

Binney, Amos, Boston, Mass. (1). Born in Boston, Mass., Oct. 18, 1803. Died in Rome, Feb. 18, 1847.

Binney, John, Boston, Mass. (3).

Blackie, Geo. S., Nashville, Tenn. (26).

Blair, Henry W., Washington, D. C. (26). Died Dec. 15, 1884.

Blake, Eli Whitney, New Haven, Conn. (1). Born Jan. 27, 1795. Died Aug. 18, 1886.

Blake, Homer Crane, New York, N. Y. (28). Born in Cleveland, Ohio, Feb. 1, 1822. Died in New York, N. Y., Jan. 20, 1880.

Blanding, William, ——, R. I. (1).

Blatchford, Thomas W., Troy, N. Y. (6).

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Blatchley, Miss S. L., New Haven, Conn. (19). Died March 13, 1873.
Boadle, John, Haddonfield, N. J. (20). Born in 1805. Died in July, 1878.
Bomford, George, Washington, D. C. (1). Born in New York, 1780. Died in Boston, Mass., March 25, 1848.
Bowles, Miss Margaretta, Columbia, Tenn. (26). Died July, 1887.
Bowron, James, South Pittsburg, Tenn. (26). Died in Dec., 1877.
Bradley, Leverette, Jersey City, N. J. (15). Died in 1875.
Braithwaite, Jos., Chambly, C. W. (11).
Briggs, Albert D., Springfield, Mass. (13). Died Feb. 20, 1881.
Briggs, Robert, Philadelphia, Pa. (29). Born May 18, 1822. Died July 24, 1882.
Brigham, Charles Henry, Ann Arbor, Mich. (17). Born in Boston, Mass., July 27, 1820. Died Feb. 19, 1879.
Brown, Andrew, Natchez, Miss. (1).
Brown, Horace, Salem, Mass. (27). Died in July, 1883.
Bull, John, Washington, D. C. (31). Born Aug. 1, 1819. Died June 9, 1884.
Burbank, L. S., Woburn, Mass. (18).
Burke, Joseph Chester, Middletown, Conn. (29). Died in 1885.
Burnap, George Washington, Baltimore, Md. (12). Born in Merrimack, N. H., Nov. 30, 1802. Died in Philadelphia, Pa., Sept. 8, 1859.
Burnett, Waldo Irving, Boston, Mass. (1). Born in Southborough, Mass., July 12, 1828. Died in Boston, Mass., July 1, 1854.
Butler, Thomas Belden, Norwalk, Conn. (10). Born Aug. 22, 1806. Died June 8, 1873.

Cairns, Frederick A., New York, N. Y. (27). Died in 1879.
Campbell, Mrs. Mary H., Crawfordsville, Ind. (22). Died Feb. 27, 1882.
Carpenter, Thornton, Camden, S. C. (7).
Carpenter, William M., New Orleans, La. (1).
Case, Leonard, Cleveland, Ohio (15). Born June 27, 1820. Died Jan. 5, 1880.
Case, William, Cleveland, Ohio (6).
Caswell, Alexis, Providence, R. I. (2). Born Jan. 29, 1799. Died in Providence, R. I., Jan. 8, 1877.
Chadbourne, Paul Ansel, Amherst, Mass. (10). Born in North Berwick, Me., Oct. 21, 1823. Died Feb. 23, 1883.
Chapman, Nathaniel, Philadelphia, Pa. (1). Born in Alexandria Co., Va., May 28, 1780. Died July 1, 1853.
Chase, Pliny Earle, Haverford College, Pa. (18). Born in Worcester, Mass., Aug. 18, 1820.
Chase, Stephen, Hanover, N. H. (2). Born in 1813. Died Aug. 5, 1851.
Chauvenet, William, St. Louis, Mo. (1). Born May 24, 1819. Died Dec. 13, 1870.
Cheesman, Louis Montgomery, Hartford, Conn. (32). Born in 1858. Died in Jan., 1885.
Cheney, Miss Margaret S., Jamaica Plain, Mass. (29). Died in 1882.
Chevreul, Michel Eugène, Paris, France (35). Born in Angiers, France, Aug. 31, 1786. Died April 9, 1889.

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Clapp, Asahel, New Albany, Ind. (1). Born Oct. 5, 1792. Died Dec. 15, 1862.

Clark, Henry James, Cambridge, Mass. (13). Born in Easton, Mass., June 22, 1826. Died in Amherst, Mass., July 1, 1873.

Clark, Joseph, Cincinnati, Ohio (5).

Clark, Patrick, Rahway, N. J. (33). Died March 5, 1887.

Clarke, A. B., Holyoke, Mass. (13).

Cleaveland, C. H., Cincinnati, Ohio (9).

Cleveland, A. B., Cambridge, Mass. (2).

Coffin, James Henry, Easton, Pa. (1). Born in Northampton, Mass., Sept. 6, 1806. Died Feb. 6, 1873.

Coffin, John H. C., Washington, D. C. (1). Born in Wiscasset, Maine, Sept. 14, 1815. Died in Washington, D. C., Jan. 8, 1890.

Coffinberry, Wright Lewis, Grand Rapids, Mich. (20). Born in Lancaster, Ohio, April 5, 1807. Died in Grand Rapids, Mich., March 26, 1889.

Colburn, E. M., Peoria, Ill. (33). Born in Rome, N. Y., Sept. 13, 1813. Died in Peoria, Ill., May 29, 1890.

Cole, Frederick, Montreal, Can. (31). Died in 1887.

Cole, Thomas, Salem, Mass. (1). Born Dec. 24, 1779. Died June 24, 1852.

Coleman, Henry, Boston, Mass. (1).

Collins, Frederick, Washington, D. C. (28). Born Dec. 5, 1842. Died Oct. 27, 1881.

Conrad, Timothy Abbott, Philadelphia, Pa. (1). Born in New Jersey, June 21, 1803. Died Aug. 9, 1877.

Cook, George H., New Brunswick, N. J. (4). Born in Hanover, Morris County, in 1818. Died in New Brunswick, N. J., Sept. 22, 1889.

Cooke, Caleb, Salem, Mass. (18). Born Feb. 15, 1838. Died June 5, 1880.

Cooper, William, Hoboken, N. J. (9). Died in 1864.

Copes, Joseph S., New Orleans, La. (11). Born Dec. 9, 1811. Died March 1, 1885.

Corning, Erastus, Albany, N. Y. (6). Born in Norwich, Conn., Dec. 14, 1794. Died April 9, 1872.

Costin, M. P., Fordham, N. Y. (30). Died June 8, 1884.

Couper, James Hamilton, Darien, Ga. (1). Born March 5, 1794. Died July 3, 1866.

Cramp, John Mockett, Wolfville, N. S. (11). Born in Kent, England, July 25, 1796. Died Dec. 6, 1881.

Crehore, John D., Cleveland, Ohio (24).

Crocker, Charles F., Lawrence, Mass. (22). Died in July, 1881.

Crocker, Miss Lucretia, Boston, Mass. (29). Died in 1886.

Crosby, Alpheus, Salem, Mass. (10). Born in Sandwich, N. H., Oct. 13, 1810. Died April 17, 1874.

Crosby, Thomas Russell, Hanover, N. H. (18). Born Oct. 22, 1816. Died March 1, 1872.

Croswell, Edwin, Albany, N. Y. (6). Born in Catskill, N. Y., May 29, 1797. Died June 13, 1871.

Crow, Wayman, St. Louis, Mo. (27). Born March 7, 1808. Died May 10, 1885.

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Cummings, Joseph R., Evanston, Ill. (13). Died in Evanston, Ill., May 4, 1890, aged 74 years.
Curry, W. F., Geneva, N. Y. (11).
Curtis, Josiah, Washington, D. C. (18). Died Aug. 1, 1883.

Dalrymple, Edwin Augustine, Baltimore, Md. (11). Born in Baltimore, Md., June 4, 1817. Died Oct. 30, 1881.
Danforth, Edward, Elmira, N. Y. (11). Died in Elmira, N. Y., June 13, 1888.
Davenport, H. W., Washington, D. C. (30).
Dayton, Edwin A., Madrid, N. Y. (7). Born in 1827. Died June 24, 1873.
Dean, Amos, Albany, N. Y. (6). Born in Barnard, Vt., Jan. 16, 1803. Died Jan. 26, 1868.
Dearborn, George H. A. S., Roxbury, Mass. (1).
Dekay, James Ellsworth, New York, N. Y. (1). Born in New York, 1792. Died Nov. 21, 1851.
Delano, Joseph C., New Bedford, Mass. (5). Born Jan. 9, 1796. Died Oct. 16, 1886.
De Laski, John, Carver's Harbor, Me. (18).
Devereux, John Henry, Cleveland, Ohio (18). Born in Boston, Mass., April 5, 1832. Died in Cleveland, Ohio, March 17, 1886.
Dewey, Chester, Rochester, N. Y. (1). Born in Sheffield, Mass., Oct. 25, 1781. Died Dec. 15, 1867.
Dexter, G. M., Boston, Mass. (11).
Dillingham, W. A. P., Augusta, Me. (17).
Dimmick, L. N., Santa Barbara, Cal. (29). Died May 31, 1884.
Dinwiddie, Hardaway H., College Station, Texas (32). Died Dec. 11, 1887.
Dinwiddie, Robert, New York, N. Y. (1). Born in Dumfries, Scotland, July 23, 1811. Died in New York, N. Y., July 12, 1888.
Dixwell, Geo. B., Boston, Mass. (29). Died April, 1885.
Doggett, George Newell, Chicago, Ill. (33). Born in Chicago, Ill., Dec. 19, 1858. Died in Fredericksburg, Va., Jan. 15, 1887.
Doggett, Mrs. Kate Newell, Chicago, Ill. (17). Born in Castleton, Vt., Nov. 5, 1828. Died in Havana, Cuba, March 13, 1884.
Doggett, Wm. E., Chicago, Ill. (17). Born Nov. 20, 1820. Died in 1876.
Doolittle, L., Lenoxville, C. E. (11). Died in 1862.
Dorr, Ebenezer Pearson, Buffalo, N. Y. (25). Born in Hartford, Vt. Died in Buffalo, N. Y., April 29, 1882.
Draper, Henry, New York, N. Y. (28). Born in New York, N. Y., March 7, 1837. Died Nov. 20, 1882.
Ducatel, Julius Timoleon, Baltimore, Md. (1). Born in Baltimore, Md., June 6, 1798. Died April 25, 1849.
Duffield, George, Detroit, Mich. (10). Born in Strasburg, Pa., July 4, 1794. Died in Detroit, Mich., June 26, 1869.
Dumont, A. H., Newport, R. I. (14).
Dun, Walter Angus, Cincinnati, Ohio (31). Born March 1, 1857. Died Nov. 7, 1887.

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Duncan, Lucius C., New Orleans, La. (10). Born in 1801. Died Aug. 9, 1855.
Dunn, R. P., Providence, R. I. (14).

Eads, James Buchanan, New York, N. Y. (27). Born May 23, 1820. Died March 8, 1887.
Easton, Norman, Fall River, Mass. (14). Died Dec. 21, 1872.
Eaton, James H., Beloit, Wis. (17). Died Jan. 5, 1877.
Elliott, Ezekiel Brown, Washington, D. C. (10). Born July 16, 1823. Died May 24, 1888.
Elsberg, Louis, New York, N. Y. (23). Born in Iserlohn, Prussia, April 2, 1836. Died in New York, N. Y., Feb. 19, 1885.
Elwyn, Alfred Langdon, Philadelphia, Pa. (1). Born in Portsmouth, N. H., July 9, 1804. Died in Philadelphia, Pa., March 15, 1884.
Ely, Charles Arthur, Elyria, Ohio (4).
Emerson, Geo. Barrell, Boston, Mass. (1). Born in Kennebunk, Me., Sept. 12, 1797. Died March 14, 1881.
Emmons, Ebenezer, Williamstown, Mass. (1). Born in Middlefield, Mass., May 16, 1799. Died October 1, 1863.
Engelmann, George, St. Louis, Mo. (1). Born in Frankfort-on-the Main, Germany, Feb. 2, 1809. Died Feb. 4, 1844.
Engstrom, A. B., Burlington, N. J. (1).
Eustis, Henry Lawrence, Cambridge, Mass. (2). Born Feb. 1, 1819. Died Jan. 11, 1885.
Evans, Edwin, Streator, Ill. (30). Died May 5, 1889.
Everett, Edward, Boston, Mass. (2). Born in Dorchester, Mass., April 11, 1794. Died in Boston, Mass., Jan. 15, 1865.
Ewing, Thomas, Lancaster, Ohio (5). Born in Ohio Co., Va., Dec. 28, 1789. Died Oct. 26, 1871.

Faries, R. J., Wauwatosa, Wis. (21). Died May 31, 1878.
Farquharson, Robert James, Des Moines, Iowa (24). Born July 15, 1824. Died Sept. 6, 1884.
Felton, Samuel Morse, Philadelphia, Pa. (29). Born in Newbury, Mass., July 19, 1809. Died in Philadelphia, Pa., Jan. 24, 1889.
Ferris, Isaac, New York, N. Y. (6). Born in New York, Oct. 9, 1798. Died in Roselle, N. J., June 16, 1873.
Feuchtwanger, Lewis, New York, N. Y. (11). Born in Fürth, Bavaria, Jan. 11, 1805. Died in New York, N. Y., June 25, 1876.
Ficklin, Joseph, Columbia, Mo. (20). Born in Winchester, Ky., Sept. 9, 1833. Died in Columbia, Mo., Sept. 6, 1887.
Fillmore, Millard, Buffalo, N. Y. (7). Born in New York, Jan. 7, 1800. Died March 8, 1874.
Fisher, Mark, Trenton, N. J. (10).
Fitch, Alexander, Hartford, Conn. (1). Born March 25, 1799. Died Jan. 20, 1859.
Fitch, O. H., Ashtabula, Ohio (7). Born in 1803. Died Sept. 17, 1882.
Foote, Herbert Carrington, Cleveland, Ohio (35). Born in 1852. Died in Cleveland, Aug. 24, 1888.
Forbush, E. B., Buffalo, N. Y. (15).

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Force, Peter, Washington, D. C. (4). Born in New Jersey, Nov. 26, 1790. Died in Washington, D. C., Jan. 23, 1868.

Ford, A. C., Nashville, Tenn. (26).

Forshey, Caleb Goldsmith, New Orleans, La. (21). Born in Somerset Co., Pa., July 18, 1812. Died in Carrollton, La., July 25, 1881.

Foster, John Wells, Chicago, Ill. (1). Born in Brimfield, Mass., March 4, 1815. Died in Chicago, Ill., June 29, 1873.

Foucon, Felix, Madison, Wis. (18).

Fowle, Wm. Bentley, Boston, Mass. (1). Born in Boston, Mass., Oct. 17, 1795. Died Feb. 6, 1865.

Fox, Charles, Grosse Ile, Mich. (7).

Fox, Joseph G., Easton, Pa. (31). Born in Adams, N. Y., Sept. 7, 1833. Died in Easton, Pa., Dec. 27, 1889.

Frazer, John Fries, Phila., Pa. (1). Born July 8, 1812. Died Oct. 12, 1872.

Freeman, Spencer Hedden, Cleveland, Ohio (29). Born Oct. 3, 1855. Died Feb. 2, 1886.

French, John William, West Point, N. Y. (11). Born in Connecticut, about 1810. Died in West Point, N. Y., July 8, 1871.

Fuller, H. Weld, Boston, Mass. (29). Died Aug. 14, 1889.

Garber, A. P., Columbia, Pa. (29). Died Aug. 26, 1881.

Gardiner, Frederic, Middletown, Conn. (23). Born in Gardiner, Me., Oct. 22, 1822. Died in Middletown, Conn., July 17, 1889.

Gavit, John E., New York, N. Y. (1). Born in New York, Oct. 29, 1819. Died in Stockbridge, Mass., Aug. 25, 1874.

Gay, Martin, Boston, Mass. (1). Born in 1804. Died Jan. 12, 1850.

Gibbon, J. H., Charlotte, N. C. (3).

Gillespie, William Mitchell, Schenectady, N. Y. (10). Born in New York, N. Y., 1816. Died in New York, Jan. 1, 1868.

Gilmor, Robert, Baltimore, Md. (1).

Glazier, W. W., Key West, Fla. (29). Died Dec. 11, 1880.

Goldmark, J., New York, N. Y. (29). Died in April, 1882.

Gould, Augustus Addison, Boston, Mass. (11). Born April 23, 1805. Died Sept. 15, 1866.

Gould, Benjamin Apthorp, Boston, Mass. (2). Born in Lancaster, Mass., June 15, 1787. Died Oct. 24, 1859.

Graham, James D., Washington, D. C. (1). Born in Virginia, 1799. Died in Boston, Mass., Dec. 28, 1865.

Gray, Alonzo, Brooklyn, N. Y. (13). Born in Townshend, Vt., Feb. 21, 1808. Died in Brooklyn, N. Y., March 10, 1860.

Gray, Asa, Cambridge, Mass. (1). Born in Paris, N. Y., Nov. 18, 1810. Died in Cambridge, Mass., Jan. 30, 1888.

Gray, James H., Springfield, Mass. (6).

Greene, Benjamin D., Boston, Mass. (1). Died Oct. 14, 1862, aged 68.

Greene, Everett W., Madison, N. J. (10). Died in 1864.

Greene, Samuel, Woonsocket, R. I. (9). Died in 1868.

Greer, James, Dayton, Ohio (20). Died in Feb., 1874.

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Griffith, Robert Eglesfield, Philadelphia, Pa. (1). Born in Philadelphia, Pa., Feb. 13, 1798. Died June 26, 1854.

Griswold, John Augustus, Troy, N. Y. (19). Born Nov. 11, 1818. Died Oct. 31, 1872.

Guest, William E., Ogdensburg, N. Y. (6).

Guyot, Arnold, Princeton, N. J. (1). Born Sept. 5, 1809. Died Feb. 8, 1884.

Habel, Louis, Northfield, Vt. (34).

Hackley, Charles William, New York, N. Y. (4). Born in Herkimer Co., N. Y., March 9, 1809. Died in New York, N. Y., January 10, 1861.

Hadley, George, Buffalo, N. Y. (6). Born June, 1813. Died Oct. 16, 1877.

Haldeman, Samuel Stehman, Chickies, Pa. (1). Born Aug. 12, 1812. Died Sept. 10, 1880.

Hale, Enoch, Boston, Mass. (1). Born in Westhampton, Mass., Jan. 29, 1790. Died in Boston, Mass., Nov. 12, 1848.

Hamilton, Jno. M., Coudersport, Pa. (33).

Hampson, Thomas, Washington, D. C. (33).

Hance, Ebenezer, Fallsington P. O., Pa. (7). Died in 1876.

Harding, Myron H., Lawrenceburg, Ind. (30.) Died Sept., 1885.

Hare, Robert, Philadelphia, Pa. (1). Born in Philadelphia, Pa., Jan. 17, 1781. Died in Philadelphia, May 15, 1858.

Harger, Oscar, New Haven, Conn. (25). Born in Oxford, Conn., Jan. 12, 1843. Died in New Haven, Conn., Nov. 6, 1887.

Harlan, Joseph G., Haverford, Pa. (8).

Harlan, Richard, Philadelphia, Pa. (1). Born in Philadelphia, Pa., Sept. 19, 1796. Died in New Orleans, La., Sept. 30, 1843.

Harris, Thaddeus William, Cambridge, Mass. (1). Born in Dorchester, Mass., Nov. 12, 1795. Died in Cambridge, Mass., Jan. 16, 1856.

Harrison, A. M., Plymouth, Mass. (29).

Harrison, Benjamin Franklin, Wallingford, Conn. (11). Born April 19, 1811. Died April 23, 1886.

Harrison, Jos., jr., Philadelphia, Pa. (12). Born in Philadelphia, Pa., Sept. 20, 1810. Died in Philadelphia, March 27, 1874.

Hart, Simeon, Farmington, Conn. (1). Born Nov. 17, 1795. Died April 20, 1853.

Hartt, Charles Frederick, Ithaca, N. Y. (18). Born in Nova Scotia, Aug. 20, 1840. Died March 18, 1878.

Haven, Joseph, Chicago, Ill. (17). Born in Dennis, Mass., Jan. 4, 1816. Died May 23, 1874.

Hawes, George W., Washington, D. C. (23). Born Dec. 31, 1848. Died June 22, 1882.

Hayden, Ferdinand Vandeveer, Philadelphia, Pa. (29). Born in Westfield, Mass., Sept. 7, 1829. Died Dec. 22, 1887.

Hayden, Horace H., Baltimore, Md. (1). Born in Winsor, Conn., Oct. 13, 1769. Died in Baltimore, Md., Jan. 26, 1844.

Hayes, George E., Buffalo, N. Y. (15).

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Hayward, James, Boston, Mass. (1). Born in Concord, Mass., June 12, 1786. Died in Boston, Mass., July 27, 1866.

Hazen, William Babcock, Washington, D. C. (30). Born in Hartford, Vt., Sept. 27, 1830. Died Jan. 16, 1887.

Hedrick, Benjamin Sherwood, Washington, D. C. (19). Born in 1826. Died Sept. 2, 1886.

Heighway, A. E., Cincinnati, Ohio (29). Born Dec. 26, 1820. Died Jan. 24, 1888.

Hempstead, G. S. B., Portsmouth, Ohio (29). Born in 1795. Died July 9, 1883.

Henry, Joseph, Washington, D. C. (1). Born in Albany, N. Y., Dec. 17, 1797. Died May 13, 1878.

Hickox, S. V. R., Chicago, Ill. (17). Died in 1872.

Hicks, William C., New York, N. Y. (34). Died in 1885.

Hilgard, Theodore Charles, St. Louis, Mo. (17). Born in Zweibrücken, Germany, Feb. 28, 1828. Died March 5, 1875.

Hill, Walter N., Chester, Pa. (29). Born Apr. 15, 1846. Died Mar. 29, 1884.

Hincks, William, Toronto, C. W. (11). Born in 1801. Died July, 1871.

Hitchcock, Edward, Amherst, Mass. (1). Born in Deerfield, Mass., May 24, 1793. Died Feb. 27, 1864.

Hoadley, John Chipman, Boston, Mass. (29). Born Dec. 10, 1818. Died Oct. 21, 1886.

Hodgson, W. B., Savannah, Ga. (10). Born 1815.

Holbrook, John Edwards, Charleston, S. C. (1). Born in Beaufort, S. C., Dec. 30, 1796. Died in Norfolk, Mass., Sept. 8, 1871.

Holman, Mrs. S. W., Boston, Mass. (29). Died May 5, 1885.

Holmes, Edward J., Boston, Mass. (29). Died in July, 1884.

Homes, Henry A., Albany, N. Y. (11). Born in Boston, Mass., March 10, 1812. Died in Albany, N. Y., Nov. 3, 1887.

Hopkins, Albert, Williamstown, Mass. (19). Born July 14, 1807. Died May 25, 1872.

Hopkins, James G., Ogdensburg, N. Y. (10). Died in 1860.

Hopkins, T. O., Williamsville, N. Y. (10). Died in 1866.

Hopkins, Wm., Lima, N. Y. (5). Died in March, 1867.

Hoppock, Albert E., Hastings-on-Hudson, N. Y. (29).

Horton, C. V. R., Chaumont, N. Y. (10). Died in 1862.

Horton, William, Craigville, N. Y. (1).

Hosford, Benj. F., Haverhill, Mass. (13). Died in 1864.

Hough, Franklin Benjamin, Lowville, N. Y. (4). Born in Martinsburgh, N. Y., July 20, 1822. Died June 11, 1885.

Houghton, Douglas, Detroit, Mich. (1). Born in Troy, N. Y., Sept. 21, 1809. Died Oct. 13, 1845.

Hovey, Edmund O., Crawfordsville, Ind. (20). Born July 15, 1801. Died March 10, 1877.

Howland, Edward Perry, Washington, D. C. (29). Born in Ledyard, N. Y., July 20, 1825. Died in Harrisburg, Pa., Sept. 12, 1888.

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Hubbert, James, Richmond, Province of Quebec (16). Died in 1868.
Howland, Theodore, Buffalo, N. Y. (15).
Hunt, Edward Bissell, Washington, D. C. (2). Born in Livingston Co., N. Y., June 15, 1822. Died in Brooklyn, N. Y., Oct. 2, 1863.
Hunt, Freeman, New York, N. Y. (11). Born in Quincy, Mass., March 21, 1804. Died in Brooklyn, N. Y., March 2, 1858.
Hyatt, Theodore, Chester, Pa. (30).

Ives, Moses B., Providence, R. I. (9). Died in 1857.
Ives, Thomas P., Providence, R. I. (10).

Jackson, Charles Thomas, Boston, Mass. (1). Born in Plymouth, Mass., June 21, 1805. Died Aug. 28, 1880.
James, Thomas Potts, Cambridge, Mass. (22). Born Sept. 1, 1803. Died Feb. 22, 1882.
Johnson, Walter Rogers, Washington, D. C. (1). Born in Leominster, Mass., June 21, 1794. Died April 26, 1852.
Johnson, William Schuyler, Washington, D. C. (31). Born Sept. 20, 1859. Died Oct. 6, 1883.
Jones, Catesby A. R., Washington, D. C. (8).
Jones, Henry A., Portland, Me. (29). Died Sept. 3, 1883.
Jones, James H., Boston, Mass. (28).

Kedzie, W. K., Oberlin, Ohio (25). Born in Kalamazoo, Mich., July 5, 1851. Died in Lansing, Mich., Apr. 10, 1880.
Keely, George W., Waterville, Me. (1). Died in 1878.
Keep, N. C., Boston, Mass. (13). Died in March, 1875.
Kennicott, Robert, West Northfield, Ill. (12). Born Nov. 13, 1835. Died in 1866.
Kerr, Washington Caruthers, Raleigh, N. C. (10). Born May 24, 1827. Died Aug. 9, 1885.
Kidder, Henry Purkitt, Boston, Mass. (29). Born Jan. 8, 1823. Died Jan. 28, 1886.
King, Mitchell, Charleston, S. C. (3). Born in Scotland, June 8, 1783. Died Nov. 12, 1862.
Kirkpatrick, James A., Philadelphia, Pa. (7). Died June 3, 1886.
Kite, Thomas, Cincinnati, Ohio (5). Died Feb. 6, 1884.
Klippart, John H., Columbus, Ohio (17). Died October, 1878.
Knickerbocker, Charles, Chicago, Ill. (17). Died in 1873.
Knight, J. B., Philadelphia, Pa. (21). Died March 10, 1879.

Lacklan, R., Cincinnati, Ohio (11).
Lapham, Increase Allen, Milwaukee, Wis. (3). Born in Palmyra, N. Y., March 7, 1811. Died in Oconomowoc, Wis., Sept. 14, 1875.
Larkin, Ethan Pendleton, Alfred Centre, N. Y. (33). Born Sept. 20, 1829. Died Aug. 23, 1887.
LaRoche, Réné, Philadelphia, Pa. (12). Born in Philadelphia, Pa., 1795. Died in Philadelphia, Dec., 1872.

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Lasel, Edward, Williamstown, Mass. (1). Born Jan. 21, 1809. Died Jan. 31, 1852.

Lawford, Frederick, Montreal, Canada (11). Died in 1866.

Lawrence, Edward, Charlestown, Mass. (18). Born June, 1810. Died Oct. 17, 1885.

Lea, Isaac, Philadelphia, Pa. (1). Born in Wilmington, Del., March 4, 1792. Died Dec. 8, 1886.

Le Conte, John Lawrence, Philadelphia, Pa. (1). Born in New York, May 13, 1825. Died Nov. 15, 1883.

Lederer, Baron von, Washington, D. C. (1).

Leonard, Rensselaer, Mauch Chunk, Pa. (33). Born in Hancock, N. Y., April 12, 1821. Died in Mauch Chunk, Pa., Oct. 26, 1888.

Lewis, Henry Carvill, Philadelphia, Pa. (26). Born in Philadelphia, Pa., Nov. 16, 1853. Died in Manchester, England, July 21, 1888.

Libbey, Joseph, Georgetown, D. C. (31). Died July 20, 1886.

Lieber, Oscar Montgomery, Columbia, S. C. (8). Born Sept. 8, 1830. Died June 27, 1862.

Lincklaen, Ledyard, Cazenovia, N. Y. (1). Born in Cazenovia, N. Y., Oct. 17, 1820. Died April 25, 1864.

Linsley, James Harvey, Stafford, Conn. (1). Born in Northford, Conn., May 5, 1787. Died in Stratford, Conn., Dec. 26, 1843.

Lockwood, Moses B., Providence, R. I. (9). Died in 1872.

Logan, William Edmond, Montreal, Canada (1). Born in Montreal, Canada, April 23, 1798. Died in Wales, June 22, 1875.

Loiseau, Emile F., Brussels, Belgium (33). Died April 30, 1886.

Loomis, Elias, New Haven, Conn. (1). Born in Willington, Conn., Aug. 7, 1811. Died in New Haven, Conn., Aug. 15, 1889.

Loosey, Charles F., New York, N. Y. (12).

Lothrop, Joshua R., Buffalo, N. Y. (15).

Lowrie, J. R., Warriorsmark, Pa. (29). Died Dec. 10, 1885.

Lull, Edward Phelps, Washington, D. C. (28). Born Feb. 20, 1836. Died March 5, 1887.

Lyford, Moses, Springfield, Mass. (22). Born in Mt. Vernon, Me., Jan. 31, 1816. Died in Portland, Me. Aug. 4, 1887.

Lyman, Chester Smith, New Haven, Conn. (4). Born in Manchester, Conn. Jan. 13, 1814, Died in New Haven, Conn., in 1889.

Lyon, Sidney S., Jeffersonville, Ind. (20). Born Aug. 4, 1808. Died June 24, 1872.

M'Conihe, Isaac, Troy, N. Y. (5).

McCutchen, A. R., Atlanta, Ga. (25). Died Nov. 21, 1887.

McElrath, Thomas, New York, N. Y. (36). Born in Williamsport, Pa., May 1, 1807. Died in New York, N. Y., June 6, 1888.

McFadden, Thomas, Westerville, Ohio (30). Born Nov. 9, 1825. Died Nov. 9, 1883.

McFarland, Walter, New York, N. Y. (36). Died July 22, 1888.

MacGregor, Donald, Houston, Texas (33). Died in Oct., 1887.

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. S., Montreal, Can. (31).
athew, Albany, N. Y. (11).
, Cambridge, Mass. (18). Died in Aug., 1873.
ames, Towanda, Pa. (29). Died in 1885.
is Hart, West Point, N. Y. (9). Born in New York, N. Y., 802. Died in New York, Sept. 16, 1871.
ge L., Montreal, Can. (31).
r, Greenfield, Mass. (1). Born in Montague, Mass., Aug. 22, ied in Greenfield, Mass., April 2, 1853.
s E., Roxbury, Mass. (10).
amin Nichols, New York, N. Y. (23). Born in Mount Holly, t. 20, 1816. Died in New York, N. Y., Dec. 26, 1883.
iam Williams, Columbus, Ohio (1). Born in Brooklyn, Conn., 804. Died in Columbus, Ohio, Feb. 27, 1859.
B., St. Louis, Mo. (27). Died in April, 1879.
Charlottesville, Va. (10).
Williams, Boston, Mass. (29). Born in Boston, April 21, ied in Boston, Nov. 30, 1888.
ge Gordon, Philadelphia, Pa. (15). Born Dec. 30, 1815. . 6, 1872.
g Bradford, Washington, D. C. (6). Born Dec. 10, 1817. . 21, 1876.
Aitken, Philadelphia, Pa. (12). Born July 30, 1829. Died 879.
Baltimore, Md. (12). Born Aug. 14, 1805. Died Oct. 24, 1880.
sby MacKnight, Cincinnati, Ohio (3). Born in Union Co., 28, 1810. Died in Beaufort, S. C., Oct. 30, 1862.
s Maria, Lynn, Mass. (4). Born in Nantucket, Mass., Aug. 1, ed in Lynn, 1889.
iam, Poughkeepsie, N. Y. (2). Born in Nantucket, Mass., 1791. Died in Poughkeepsie, N. Y., April 19, 1868.
. H., Florence, Ala. (17).
ian, Bradford, Mass. (6). Born in Minot, Me., May 16, ed in Bradford, Mass., July 8, 1866.
iam, Concord, Mass. (18). Died April 27, 1877.
is Henry, Rochester, N. Y. (10). Born near Aurora, N. Y., 1818. Died Dec. 17, 1881.
Mary E., Rochester, N. Y. (31). Died in 1884.
B., Nashville, Tenn. (26).
uel George, Philadelphia, Pa. (1). Born in Philadelphia, 26, 1799. Died in Philadelphia, May 15, 1851.
ler B., New York, N. Y. (36). Died Aug. 12, 1889.
min Franklin, Manhattan, Kansas (25). Born in Orring- Aug. 11, 1817. Died Nov. 21, 1879.
, Montreal, Can. (31). Died July, 1885.
am Heberdom, Cincinnati, Ohio (30). Born Sept. 30, 1818. . 1, 1882.

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Nagel, Herman, St. Louis, Mo. (30). Born in Tritzwalk, Germany, May 28, 1820. Died in St. Louis, Mo., Feb. 18, 1889.

Newland, John, Saratoga Springs, N. Y. (28). Died Jan. 18, 1880.

Newton, E. H., Cambridge, N. Y. (1).

Nichols, Charles A., Providence, R. I. (17). Born Jan. 4, 1826. Died Oct. 20, 1877.

Nichols, William Ripley, Boston, Mass. (18). Born April 30, 1847. Died July 14, 1886.

Nicholson, Thomas, New Orleans, La. (21).

Nicollet, Jean Nicholas, Washington, D. C. (1). Born in Savoy, France, July 24, 1786. Died in Washington, D. C., Sept. 11, 1843.

Norton, John Pitkin, New Haven, Conn. (1). Born July 19, 1822. Died Sept. 5, 1852.

Norton, William Augustus, New Haven, Conn. (6). Born in East Bloomfield, N. Y., Oct. 25, 1810. Died Sept. 21, 1883.

Noyes, James Oscar, New Orleans, La. (21). Born in Niles, N. Y., June 14, 1829. Died in New Orleans, La., Sept. 11, 1872.

Nutt, Cyrus, Bloomington, Ind. (20). Born in Trumbull Co., Ohio, Sept. 4, 1814. Died in Bloomington, Aug. 23, 1875.

Oakes, Wm., Ipswich, Mass. (1). Born July 1, 1799. Died July 31, 1848.

Ogden, Robert W., New Orleans, La. (21). Died March 24, 1878.

Ogden, William Butler, High Bridge, N. Y. (17). Born in New York, N. Y., 1805. Died in New York, Aug. 3, 1877.

Oliver, Miss Mary E., Ithaca, N. Y. (20).

Olmsted, Alexander Fisher, New Haven, Conn. (4). Born Dec. 20, 1822. Died May 5, 1853.

Olmsted, Denison, New Haven, Conn. (1). Born in East Hartford, Conn., June 18, 1791. Died in New Haven, Conn., May 13, 1859.

Olmsted, Denison, jr., New Haven, Conn. (1). Born Feb. 16, 1824. Died Aug. 15, 1846.

Orton, James, Poughkeepsie, N. Y. (18). Born in Seneca Falls, N. Y., April 21, 1830. Died in Peru, S. A., Sept. 24, 1877.

Osbun, Isaac J., Salem, Mass. (29).

Otis, George Alexander, Washington, D. C. (10). Born in Boston, Mass., Nov. 12, 1830. Died Feb. 28, 1881.

Owen, Richard, New Harmony, Ind. (20). Born in Scotland, Jan. 6, 1810. Died in New Harmony, March 24, 1890.

Packer, Harry E., Mauch Chunk, Pa. (30). Died Feb. 1, 1884.

Painter, Jacob, Lima, Pa. (23). Died in 1876.

Painter, Minshall, Lima, Pa. (7).

Parker, Wilbur F., West Meriden, Conn. (23). Died in 1876.

Parkman, Samuel, Boston, Mass. (1). Born in 1816. Died Dec. 15, 1854.

Parry, Charles C., Davenport, Iowa (6). Born in Admington, Worcestershire, Eng., Aug. 28, 1823. Died in Davenport, Iowa, Feb. 20, 1890.

Parsons, Henry Betts, New York, N. Y. (30). Born Nov. 20, 1855. Died Aug. 21, 1885.

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Payn, Charles H., Saratoga Springs, N. Y. (28). Born May 16, 1814. Died Dec. 20, 1881.

Peirce, Benjamin Osgood, Beverly, Mass. (18). Born in Beverly, Sept. 26, 1812. Died in Beverly, Nov. 12, 1883.

Peirce, Benjamin, Cambridge, Mass. (1). Born in Salem, Mass., April 4, 1809. Died in Cambridge, Mass., Oct. 6, 1880.

Perch, Bernard, Frankford, Pa. (35). Born in 1850. Died in 1887.

Perkins, George Roberts, Utica, N. Y. (1). Born in Otsego Co., N. Y., May 3, 1812. Died in New Hartford, N. Y., Aug. 22, 1876.

Perkins, Henry C., Newburyport, Mass. (18). Born Nov. 13, 1804. Died Feb. 2, 1873.

Perry, John B., Cambridge, Mass. (16). Born in 1820. Died Oct. 3, 1872.

Perry, Matthew Calbraith, New York, N. Y. (10). Born in South Kingston, R. I., 1795. Died in New York, March 4, 1858.

Phelps, Mrs. Almira Hart Lincoln, Baltimore, Md. (13). Born in Berlin, Conn., July 15, 1793. Died in Berlin, July 15, 1884.

Philbrick, Edw. S., Brookline, Mass. (29). Born in Boston, Mass., Nov. 20, 1827. Died in Brookline, Mass., Feb. 13, 1889.

Phillips, John C., Boston, Mass. (29). Born in 1839. Died Mar. 1, 1885.

Piggot, A. Snowden, Baltimore, Md. (10).

Pim, Bedford Clapperton Trevelyan, London, Eng. (33). Born in England, June 12, 1826. Died Oct., 1886.

Platt, W. G., Philadelphia, Pa. (32). Died Nov., 1885.

Plumb, Ovid, Salisbury, Conn. (9).

Pope, Charles Alexander, St. Louis, Mo. (12). Born in Huntsville, Ala., March 15, 1818. Died in Paris, Mo., July 6, 1870.

Porter, John Addison, New Haven, Conn. (14). Born in Catskill, N. Y., March 15, 1822. Died in New Haven, Conn., Aug. 25, 1866.

Potter, Stephen H., Hamilton, Ohio (30). Born Nov. 10, 1812. Died Dec. 9, 1883.

Pourtalès, Louis François de, Cambridge, Mass. (1). Born March 4, 1824. Died July 19, 1880.

Pruyn, John Van Schaick Lansing, Albany, N. Y. (1). Born in Albany, N. Y. June 22, 1811. Died in Clifton Springs, N. Y., Nov. 21, 1877.

Pugh, Evan, Centre Co., Pa. (14). Born Feb. 29, 1828. Died April 29, 1864.

Pulsifer, Sidney, Philadelphia, Pa. (21). Died March 24, 1884.

Putnam, Mrs. Frederick Ward, Cambridge, Mass. (19). Born in Charlestown, Mass., Dec. 29, 1838. Died in Cambridge, Mass., March 10, 1879.

Putnam, J. Duncan, Davenport, Iowa (27). Born Oct. 18, 1855. Died Dec. 10, 1881.

Read, Ezra, Terre Haute, Ind. (20). Died in 1877.

Redfield, William C., New York, N. Y. (1). Born near Middletown, Conn., March 26, 1789. Died Feb. 12, 1857.

Resor, Jacob, Cincinnati, Ohio (8). Died in 1871.

Robb, James, Fredericton, N. B. (4).

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Robinson, Coleman T., Buffalo, N. Y. (15). Born in Putnam Co., N. Y. in 1838. Died near Brewster's Station, N. Y., May 1, 1872.

Rochester, Thomas Fortescue, Buffalo, N. Y. (35). Born Oct. 8, 1823. Died May 24, 1887.

Rockwell, John Arnold, Norwich, Conn. (10). Born in Norwich, Conn., August 27, 1803. Died in Washington, D. C., February 10, 1861.

Roeder, F. A., Cincinnati, Ohio (30).

Rogers, Henry Darwin, Glasgow, Scotland (1). Born in Philadelphia, Pa., Aug. 1, 1808. Died in Glasgow, Scotland, May 29, 1866.

Rogers, James Blythe, Philadelphia, Pa. (1). Born in Philadelphia, Pa., Feb. 11, 1802. Died in Philadelphia, June 15, 1852.

Rogers, Robert Emple, Philadelphia, Pa. (18). Born in Baltimore, Md., March 29, 1813. Died Sept. 6, 1884.

Rogers, William Barton, Boston, Mass. (1). Born in Philadelphia, Pa , Dec. 7, 1804. Died in Boston, May 30, 1882.

Root, Elihu, Amherst, Mass. (25). Born Sept. 14, 1845.

Sager, Abram, Ann Arbor, Mich. (6). Born in Bethlehem, N. Y., Dec. 22, 1811. Died August 6, 1877.

Sanders, Benjamin D., Wellsburg, W. Va. (19).

Scammon, Jonathan Young, Chicago, Ill. (17). Born in Whitefield, Me. in 1812. Died in Chicago, Ill., March 17, 1890.

Schaeffer, Geo. C., Washington, D. C. (1). Died in 1873.

Schley, William, New York, N. Y. (28). Died in 1882.

Schram, Nicholas Hallock, Newburgh, N. Y. (33). Died in Newburgh, N. Y., aged 54 years, 1 month and 2 days.

Scott, Joseph, Dunham, C. E. (11). Died in 1865.

Seaman, Ezra Champion, Ann Arbor, Mich. (20). Born Oct. 14, 1805. Died July 15, 1880.

Senecal, L. A., Montreal, Can. (31).

Senter, Harvey S., Aledo, Ill. (20). Died in 1875.

Seward, William Henry, Auburn, N. Y. (1). Born in Florida, N. Y., May 16, 1801. Died in Auburn, N. Y., Oct. 10, 1872.

Sheppard, William, Drummondville, Province of Quebec, Can. (11). Born in 1783. Died in 1867.

Sherwin, Thomas, Dedham, Mass. (11). Born in Westmoreland, N. H., March 26, 1799. Died in Dedham, Mass., July 23, 1869.

Sill, Elisha N., Cuyahoga Falls, Ohio (6). Born in 1801. Died April 26, 1888.

Silliman, Benjamin, New Haven, Conn. (1). Born in North Stratford, Conn., August 8, 1779. Died in New Haven, Conn., Nov. 22, 1864.

Silliman, Benjamin, New Haven, Conn. (1). Born in New Haven, Conn., Dec. 4, 1816. Died Jan. 14, 1885.

Simpson, Edward, Washington, D. C. (28). Born in New York, N. Y., March 3, 1824. Died in Washington, D. C., Dec. 1, 1888.

Skinner, George, Kalida, Ohio (33).

Skinner, John B., Buffalo, N. Y. (15). Died in 1871.

Slack, J. H., Philadelphia, Pa. (12).

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Smith, Charles A., St. Louis, Mo. (27). Died in 1884.

Smith, David P., Springfield, Mass. (29). Born Oct. 1, 1830. Died Dec. 26, 1880.

Smith, Mrs. Erminnie Adelle, Jersey City, N. J. (25). Born April 26, 1836. Died June 9, 1886.

Smith, John Lawrence, Louisville, Ky. (1). Born near Charleston, S. C., Dec. 17, 1818. Died Oct. 12, 1883.

Smith, J. V., Cincinnati, Ohio (5).

Smith, James Young, Providence, R. I. (9). Born in Groton, Conn., Sept. 15, 1809. Died March 26, 1876.

Smith, Lyndon Arnold, Newark, N. J. (9). Born in Haverhill, N. H., November 11, 1795. Died in Newark, N. J., December 15, 1865.

Snell, Ebenezer Strong, Amherst, Mass. (2). Born in North Brookfield, Mass., October 7, 1801. Died in Amherst, Mass., Sept., 1877.

Sparks, Jared, Cambridge, Mass. (2). Born in Willington, Conn., May 10, 1819. Died in Cambridge, Mass., March 14, 1866.

Spinzig, Charles, St. Louis, Mo. (27). Died Jan. 22, 1882.

Squier, Ephraim George, New York, N. Y. (18). Born in Bethlehem, N. Y., June 17, 1821. Died in Brooklyn, N. Y., April 17, 1888.

Stearns, Josiah A., Boston, Mass. (29).

Stearns, Silas, Pensacola, Fla. (28). Died Aug. 2, 1888.

Steele, Joel Dorman, Elmira, N. Y. (33). Born in Lima, N. Y., May 14, 1836. Died May 25, 1886.

Stevenson, James, Washington, D. C. (29). Born in Maysville, Ky., Dec. 24, 1840. Died in New York, N. Y., July 23, 1888.

Stimpson, Wm., Chicago, Ill. (12). Born Feb. 14, 1832. Died May 26, 1872.

Stone, Leander, Chicago, Ill. (32). Died April 2, 1888.

Stone, Samuel, Chicago, Ill. (17). Born Dec. 6, 1798. Died May 4, 1876.

St. John, Joseph S., Albany, N. Y. (28). Died Nov. 23, 1882.

Straight, H. H., Chicago, Ill. (25). Died Nov. 17, 1886.

Sullivan, Algernon Sidney, New York, N. Y. (36). Born April 5, 1826. Died Dec. 4, 1887.

Sullivant, William Starling, Columbus, Ohio (7). Born near Columbus, O., Jan 15, 1803. Died in Columbus, O., April 30, 1873.

Sutton, George, Aurora, Ind. (20.) Died June 13, 1886.

Swain, James, Fort Dodge, Iowa (21). Born in 1816. Died in 1877.

Tallmadge, James, New York, N. Y. (1). Born in Stamford, N. Y., Jan. 20, 1778. Died in New York, N. Y., Oct. 3, 1853.

Taylor, Arthur F., Cleveland, Ohio (29). Born Dec. 10, 1853. Died June 28, 1883.

Taylor, Richard Cowling, Philadelphia, Pa. (1). Born in England, Jan. 18, 1789. Died in Philadelphia, Pa., November 26, 1851.

Taylor, Robert N., Tollesboro, Ky. (37). Died Aug. 13, 1888.

Tenney, Sanborn, Williamstown, Mass. (17). Born in January, 1827. Died July 11, 1877.

Teschemacher, James Englehert, Boston, Mass. (1). Born in Nottingham, England, June 11, 1790. Died near Boston, Nov. 9, 1853.

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Thompson, A. Remsen, New York, N. Y. (1). Died in Oct., 1879.
Thompson, Alexander, Aurora, N. Y. (1).
Thompson, Charles Oliver, Terre Haute, Ind. (29). Born in East Windsor Hill, Conn., Sept. 25, 1835. Died in Terre Haute, Ind., March 17, 1885.
Thompson, Zadock, Burlington, Vt. (1). Born in Bridgewater, Vt., May 23, 1796. Died in Burlington, Vt, Jan 19, 1856.
Thomson, Henry R., Crawfordsville, Ind. (30). Died in 1884.
Thurber, Isaac, Providence, R. I. (9).
Tileman, John Nicholas, Sandy, Utah (33). Born in Horhun, Denmark, March 28, 1845. Died in Salt Lake City, Utah, Sept. 4, 1888.
Tillman, Samuel Dyer, Jersey City, N. J. (15). Born April, 1815. Died Sept. 4, 1875.
Tobin, Thomas W., Louisville, Ky. (30). Died Aug. 4, 1883.
Todd, Albert, St. Louis, Mo. (27). Born March 4, 1813. Died April 30, 1885.
Tolderoy, James B., Fredericton, N. B. (11).
Torrey, John, New York, N. Y. (1). Born in New York, N. Y., Aug. 15, 1796. Died in New York, March 10, 1873.
Torrey, Joseph, Burlington, Vt. (2). Born in Rowley, Mass., Feb. 2, 1797. Died in Burlington, Vt., Nov. 26, 1867.
Totten, Joseph Gilbert, Washington, D. C. (1). Born in New Haven, Conn., August 23, 1788. Died in Washington, D. C., April 22, 1864.
Townsend, Howard, Albany, N. Y. (10). Born Nov. 22, 1823. Died Jan. 6, 1867.
Townsend, John Kirk, Philadelphia, Pa. (1). Born Aug. 10, 1809. Died Feb. 16, 1851.
Townsend, Robert, Albany, N. Y. (9). Born 1799. Died Aug. 15, 1866.
Troost, Gerard, Nashville, Tenn. (1). Born in Bois-le-Duc, Holland, March 15, 1776. Died in Nashville, Tenn., Aug. 14, 1850.
Tuomey, Michael, Tuscaloosa, Ala. (1). Born in Ireland, September 29, 1805. Died in Tuscaloosa, Ala., March 20, 1857.
Tweedale, John B., St. Thomas, Can. (35). Born in Ormskirk, Lancashire, Eng., Oct. 16, 1821. Died in St. Thomas, Can., Nov. 18, 1889.
Tyler, Edward R., New Haven, Conn. (1). Born Aug. 3, 1800. Died Sept. 28, 1848.

Vancleve, John W., Dayton, Ohio (1).
Vanuxem, Lardner, Bristol, Pa. (1). Born in Philadelphia, Pa., July 23, 1792. Died in Bristol, Pa., June 25, 1848.
Vaux, William Sanson, Philadelphia, Pa. (1). Born in Philadelphia, May 19, 1811. Died in Philadelphia, May 5, 1882.

Wadsworth, James Samuel, Genesee, N. Y. (2). Born in Geneseo, N. Y., October 30, 1807. Died near Chancellorville, Va., May 8, 1864.
Wagner, Tobias, Philadelphia, Pa. (9).
Walker, J. R., Bay Saint Louis, Miss. (19). Born Aug. 7, 1830. Died June 22, 1887.
Walker, Joseph, Oxford, N. Y. (10).

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Walker, Sears C., Washington, D. C. (1). Born March 28, 1805. Died January 30, 1853.

Walker, Timothy, Cincinnati, Ohio (4). Born in Wilmington, Mass., Dec. 1, 1802. Died in Cincinnati, Ohio, Jan. 15, 1856.

Walling, H. F., Cambridge, Mass. (16). Died April 8, 1888.

Walsh, Benjamin D., Rock Island, Ill. (17). Born in Frome, England, Sept. 21, 1808. Died in Rock Island, Ill., Nov. 18, 1869.

Wanzer, Ira, Brookfield, Conn. (18). Born April 17, 1796. Died March 5, 1879.

Warnecke, Carl, Montreal, Can. (31). Died May 14, 1886.

Warren, Geo. Washington, Boston, Mass. (18). Died in 1884.

Warren, Gouverneur Kemble, Newport, R. I. (12). Born in Cold Spring N. Y., Jan. 8, 1830. Died in Newport, R. I., Aug. 8, 1882.

Warren, John Collins, Boston, Mass. (1). Born in Boston, Mass., Aug. 1, 1778. Died in Boston, May 4, 1856.

Warren, Samuel D., Boston, Mass. (29). Born in 1817. Died May 11, 1888.

Watertown, Charles, Wakefield, Eng. (1). Born in Wakefield, England. Died in Wakefield, May 26, 1865.

Watkins, Samuel, Nashville, Tenn. (26).

Watson, James Craig, Ann Arbor, Mich. (13). Born in Fingal, Canada, Jan. 28, 1838. Died in Madison, Wis., Nov. 23, 1880.

Webster, Horace B., Albany, N. Y. (1). Born in 1812. Died Dec. 8, 1843.

Webster, J. W., Cambridge, Mass. (1). Born in 1793. Died Aug. 30, 1850.

Webster, M. H., Albany, N. Y. (1).

Weed, Monroe, Wyoming, N. Y. (6). Died in 1867.

Welch, Mrs. G. O., Lynn, Mass. (21). Died in June, 1882.

Welsh, John, Philadelphia, Pa. (33). Died May, 1886.

Weyman, George W., Pittsburgh, Pa. (6). Born April, 1832. Died July 16, 1864.

Wheatland, Richard H., Salem, Mass. (13). Born July 6, 1830. Died Dec. 21, 1863.

Wheatley, Charles M., Phœnixville, Pa. (1). Died May 6, 1882.

Wheeler, Arthur W., Baltimore, Md. (29). Born in March, 1859. Died Jan. 6, 1881.

Whitall, Henry, Camden, N. J. (33).

White, Samuel S., Philadelphia, Pa. (23). Died Dec. 30, 1879.

Whiting, Lewis E., Saratoga Springs, N. Y. (28). Born March 7, 1815. Died Aug. 2, 1882.

Whitman, Edmund B., Cambridge, Mass. (29). Died Sept. 2, 1883.

Whitman, Wm. E., Philadelphia, Pa. (23). Died in 1875.

Whitney, Asa, Philadelphia, Pa. (1). Born Dec. 1, 1791. Died June 4, 1874.

Whittlesey, Charles, Cleveland, Ohio (1). Born in Southington, Conn., Oct. 5, 1808. Died Oct. 18, 1886.

Whittlesey, Charles C., St. Louis, Mo. (11). Died in 1872.

Wight, Orlando W., Detroit, Mich. (34).

Wilber, G. M., Pine Plains, N. Y. (19).

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Wilder, Graham, Louisville, Ky. (30). Born July 1885.

Willard, Emma C. Hart, Troy, N. Y. (15). Born 23, 1787. Died in Troy, N. Y., April 15, 18

Williams, Frank, Buffalo, N. Y. (25). Died Aug.

Williams, P. O., Watertown, N. Y. (24).

Williamson, Robert S., San Francisco, Cal. (1 about 1825.

Wilson, C. H., Belize, British Honduras (30).

Wilson, Mrs. Mary V. C., Mobile, Ala. (37). Bo Ala., Jan. 29, 1840. Died near Tullahoma, T

Wilson, W. C., Carlisle, Pa. (12).

Winlock, Joseph, Cambridge, Mass. (5). Born 6, 1826. Died in Cambridge, Mass., June 1

Woerd, Chas. Vander, Waltham, Mass. (29). B Oct. 6, 1821. Died near Dagget, Cal., Dec.

Woodbury, Levi, Portsmouth, N. H. (1). Born Dec. 22, 1789. Died Sept. 4, 1851.

Woodman, John Smith, Hanover, N. H. (11). Sept. 6, 1819. Died in Durham, N. H., May

Woodward, Joseph Janvier, Washington, D. C delphia, Pa., Oct. 30, 1833. Died near that

Worthen, Amos Henry, Springfield, Ill. (5). Bo May 6, 1888.

Wright, Elizur, Boston, Mass. (31). Born in So 12, 1804. Died Nov. 20, 1885.

Wright, Harrison, Wilkes Barre, Pa. (29). Bo Feb. 20, 1885.

Wright, John, Troy, N. Y. (1).

Wyman, Jeffries, Cambridge, Mass. (1). Born in 11, 1814. Died in Bethlehem, N. H., Sept. 4,

Wyckoff, William Cornelius, New York, N. Y. (N. Y., May 28, 1832. Died in Brooklyn, N.

Yarnall, M., Washington, D. C. (26). Born in 18

Youmans, Edward Livingston, New York, N. Y. N. Y., June 3, 1821. Died Jan. 18, 1887.

Young, Ira, Hanover, N. H. (1). Born in Leban Died in Hanover, N. H., Sept. 14, 1858.

Zentmayer, Joseph, Philadelphia, Pa. (29). Died

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ADDRESS

BY

J. W. POWELL,

THE RETIRING PRESIDENT OF THE ASSOCIATION.

EVOLUTION OF MUSIC FROM DANCE TO SYMPHONY.

A BLUE egg may become a robin. The latent life sequestered by marble walls may be warmed into activity and gather to itself the crumbs from a cottage table and weave therefrom the tissues of life — feet to perch among the blossoms, wings to fly among the trees, eyes to revel in the scenes disclosed by sunlight, and vocal organs to sing the song of love to mate.

A tiny seed may become a "big tree," for, warmed into life, it sends its rootlets into the nourishing earth and its branches into the vivifying air, and gathers materials with which to build a sequoyah, that stands for centuries as a glory in the forest of the sierra.

The rill born of a summer shower carries the sand from the hillside and gives it to the brook, and the brook bears it on to the river, and the river transports it to the sea, and the impregnated tide finds a nest beneath the waves and in it lays the egg of an island. Then this boss on the floor of the ocean has the power to gather about it more sands as they come from the distant hills, and still more sands. Every summer shower gives it more, and every storm adds to the sands that are thus buried beneath the sea, until at last an island is hatched, as it lifts its head above the waves.

Robins grow to be robins by minute increments; trees grow to be trees by minute increments; islands grow to be islands by minute increments. There is an aphorism current in the world that

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like begets its like; it is but half the truth. Whatever is, changes, and no repetition comes through all the years of time; some minute change must ever intervene. Among living things one generation follows another, always with some change, and change on change in sequent reproduction as the stream of life flows on, results at last in transformation. This slow but sure metamorphosis is called evolution, and the scientific world is engaged in the formulation of its laws.

The laws of animal and vegetal progress, otherwise called biotic evolution, do not apply to mankind in civilization. Biotic evolution is progress in bodily function; human evolution is progress in culture. The one is dependent on the laws of vitality, the other dependent on the laws of psychology. The first great law of biotic evolution is denominated *the survival of the fittest in the struggle for existence*. This law does not directly apply to man in his progress in culture. The bad are not killed off by any natural process in order that the good may survive and propagate their kind. Human progress is by human endeavor, by conscious and designed effort for improvement in condition.

The second great law in biotic evolution is denominated *adaptation to environment*. But man is not adapted to environment. He adapts the environment to himself by creating that which he desires. For example, no natural protection to his body is developed by which he is adapted to a boreal climate, but he adapts that climate to himself, modifies it in its effect upon himself by building a house and creating a home climate at the fireside. And when outside of his home, he protects himself with clothing and creates a personal climate and laughs at the winds that drift the snow. Man is not adapted to environment, but he adapts his arts to environment, and creates new conditions to please himself.

The third great law of biotic evolution is denominated *progress in heterogeneity*. With time animals become more and more diverse in structure and function. Kinds or species multiply. But this law is reversed with men in civilization, for they become more and more homogeneous. The tendency is not to differentiate into species, some with horns and hoofs, some with tusks and claws and some with arms and some with wings. The tendency is not towards specific differentiation, but towards specific homogeneity.

There is, however, another kind of differentiation that develops by culture, which may be denominated *qualitative differentiation*.

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Human beings do not develop along divergent lines, but along parallel lines, and they differ mainly in the degree in which they have made progress. Human evolution develops not different kinds of men, but different qualities of men. The apple tree under human culture does not develop in one line to bear peaches, another to bear plums and another to bear pine-apples. But the fruit of one tree is sour and that of another is sweet. One is dwarfed, gnarled and bitter, another is large, roseate and luscious. Human progress is such culture. It develops different qualities and degrees of the same thing. There are apple trees that bear nothing but sorry fruits. There are tribes of the world that are all savages. The trees of higher culture bear fruits of diverse qualities. The well-developed pippin, the diseased pippin and the shrivelled knot of bitterness grow on the same tree. So in lands of highest culture men are good and bad, wise and unwise, but they do not thus become specifically different.

The fourth great law of biotic evolution is denominated *progress in integration*. The differentiating parts also become more and more interdependent. The organ which can best subserve its purpose is less efficient in performing an unwonted function; it therefore becomes dependent upon other organs, and the interdependence of all the parts of the same organism increases with evolution. Society is an organism. The people organized as a body-politic and constituting a nation become interdependent, and each one is interested in the common welfare. In the growth of society through the organization of kindred into clans, and of clans into tribes, and ultimately of tribes into nations, great progress in integration is made, and it receives its highest development when despotism is organized. If we study the progress of society through these stages only, we are led to conclude that biotic evolution and human culture follow the same laws, for the integration of mankind in despotic nations is measured by the perfection of despotic governments. The highest integration is secured with hereditary rulers, privileged classes and enslaved common people.

The progress of mankind from despotism to liberty has been one vast system of warfare against integration, until in perfect liberty under free institutions this integration is destroyed, and the biotic law is repealed in its application to mankind. The development of liberty is the overthrow of the fourth law of animal evolution.

Liberty means freedom to the individual and is secured by es-

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tablishing interdependence of industries; thus man transfers despotism from himself to his inventions.

No cruel law of destruction belongs to mankind. No brutal adaptation to environments occurs in the course of human culture. No differentiation into antagonistic species is found. And liberty destroys despotic integration.

The laws of biotic evolution do not apply to mankind. There are men in the world so overwhelmed with the grandeur and truth of biotic evolution that they actually believe that man is but a two-legged beast whose progress in the world is governed by the same laws as the progress of the serpent or the wolf; and so science is put to shame.

Since the doctrines of evolution have been established, the basis of systematic classification has been changed. Artificial categories have given place to natural categories in such a manner that the classes are believed to represent genetic relations. The search for natural categories began anterior to the establishment of the laws of biotic evolution, and the new philosophy would be unrecognized but for the work which systematic biology has already done. Natural classifications and the laws of hereditary descent develop together and are interdependently established. Still it remains that genetic biology, or the science of the laws of the progress of life, imposes conditions upon systematic biology, for a natural classification must reveal the fundamental epochs and phases of evolution.

As human progress is not upon divergent lines, but upon the same line to the goal of a higher life, men must be classified not by biotic kinds, but by degrees of culture; and the three great culture stages, not three great kinds of men, be it understood, have been called savagery, barbarism and civilization, to which a fourth may well be added, that of modern civilization,—the stage of enlightenment.

That which makes man more than the beast is culture. Culture is human evolution; not the development of man as an animal, but the evolution of the human attributes of man. Culture is the product of human endeavor. This is the burden of my argument.

In man's progress from savagery to enlightenment, he has transferred the laws of beast evolution from himself to his inventions and, relieved of the load, he has soared away to the goal of his destiny on the wings of higher laws.

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The evolution of music has been presented as an illustration of this fact. Man as a poet has not developed by the survival of the fittest. There has been no natural system of laws by which the bad musician has been killed and the good musician permitted to live and propagate his kind. There has been no system of natural selection to kill poor singers and cheap fiddlers.

There is no adaptation of musicians to environment. There are no aquatic musicians; there are no aërial musicians; there are no tropical musicians; there are no boreal musicians as those terms are used in biology. The prima donna that sings in Rome may sing in St. Petersburg. The artist on the violin may enrapture the people in Toronto, in Washington, or in Mexico, and an orchestra may play on the land and on the sea.

Again there has been no progress in the differentiation of musicians. There is no musical species. There is no distinct race of prima-donnas. There is no endogenous clan of organists. Musical folk spring up among the people everywhere. Of two children of the same parents, the one will be musical and the other will not be. A sister will play the violin with beauty and a brother may love nothing better than an accordeon.

Every nation and tribe on the face of the earth has developed its own musicians, and when a great artist springs up in any land he travels the world and delights all the people of civilization. Ole Bull like Orpheus would make the stony hearts of all men dance, and Jenny Lind could sing a song of sorrow to weeping multitudes in any city of Christendom, and if the angels loved not her music small be the meed of praise for angels.

And, lastly, there is no integration of musicians. They are not organized into one body-politic. They do not inhabit one little nook of the world. They are not gathered by themselves on one isle of the sea. The king of players is metaphoric king, the queen of singers is metaphoric queen.

But though these laws of evolution do not apply to musicians, they yet do apply to music itself. Man has transferred them from himself to his musical inventions. Ever there has been a survival of the fittest. The music of savagery is lost in barbarism. The songs of barbarism are lost in civilization, and modern music is replacing the music of our fathers. So the old grows into the new by the survival of the fittest; not by natural selection, but by human selection, for men choose to keep the music they love the best.

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There has been progress by differentiation in music. Gradually music has developed into distinct parts, and with the invention of musical instruments, musical compositions have been produced adapted to each. There is the music of the organ, the piano, the flute, the violin, and instruments too many to tell, and thus the world is filled with varied music.

Music has been adapted to environment. There is music for the dance, and for the battle; music for the wedding, and the funeral; music for the theatre and the temple; and there is music about everything: the land, the sea and the air, the valley and the mountain, the flower and the forest, the fountain and the river, the worm and the serpent, the zephyr and the tempest. There is music for all peoples in all climes, in all conditions; the varieties of music parallel every human thought.

There is integration of music. When a band plays organized music for the military parade, many instruments combine to play their parts in harmony. There is organized music for the temple where the choir and the instruments combine to make music for prayer and praise. But the highest development of musical integration is found in the orchestra where the parts of the symphony are played in sweet unison, in grand harmony and sublime sequence, guided by the magic baton of the leader.

Music is the invention of mankind, not of one man, but of all men, of composers, performers and hearers. Music has come down the stream of time, and as the rivers grow from source to sea, so music grows from primal time to vast eternity.

In the same manner we may take up any one of the elements of human culture and develop the laws of its evolution and find that all culture comes by human endeavor. All arts, all institutions, all languages, all opinions, have grown in obedience to the laws of evolution as set forth, and in the exercise of all these human activities man himself has been developed; so the laws of biotic evolution apply not to mankind. Beast is beast, man is man.

I have affirmed that the laws of biotic evolution do not apply to human culture; to make this clear, concrete demonstration is necessary. On this occasion one of the æsthetic arts will be used for this purpose; the evolution of music will be portrayed and its laws developed, and it will be followed briefly through the four stages of culture: savagery, barbarism, civilization and enlightenment.

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The classific categories of biology should represent genesis by differentiation, but it has been shown that man cannot thus be classified. Man by his genius has transferred the application of the four great laws of biotic evolution from himself to his inventions. Human inventions evolve by human selection, and there is a survival of the fittest, an adaptation to environment, a progress in differentiation, and a progress in integration. Human inventions, therefore, should be classified in such a manner as to exhibit their genesis by differentiation.

If we classify the fine arts on these principles we must place them in four groups, as we find them arising from four germs. It is true that their development has been more or less interdependent, yet they have four origins and have developed along four lines, both in form and motive.

Fetich carving was the germ of sculpture. Stone, bone, shell, wood, and various other materials were used by the sculptor in which to carve the forms of his beast gods. Carving begun in this rude way developed at last along two lines, one leading to idolatry, and the other to sculpture.

Picture-writing was the germ of painting. Early man daubed rude pictures on bark and other materials and etched them on stone. The alphabetic arts also sprang from this source, as writing, printing and telegraphing.

Mythology was the germ of drama. Early man believed the animals to be the creators and movers of his universe and the stories of the doings of beasts constituted the first drama. Later romance sprang from the same source, and from romance biography and history. Along another line from the same germ sprang science.

The dance was the germ of music and poetry. Poetry derived its form from the dance and its earliest motive from mythology. The evolution of music will be set forth more fully.

Sculpture represents material forms in solid matter, as wood, clay, stone, ivory and metal.

Painting represents forms and scenes of nature and human life in color, as light, shade and hue, through the aid of form perspective, distance perspective and aërial perspective.

Drama represents scenes in the life of human and mythic heroes by personation or mimicry, combined with literary presentation.

Romance represents biography and history in fictitious tales.

Music represents ideas in sound, by rhythm, melody, harmony and symphony.

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Poetry represents psychic pictures by metaphor, through the aid of rhythmic literature, sometimes using rhyme and alliteration.

The arts have thus been described by defining their forms, but each has something more as a reason for its being an æsthetic art—a purpose to fulfil. The motive of all the æsthetic arts is to reach the intellect through symbols, and thus kindle the emotions. All art is therefore symbolic and emotional.

Let us turn to the evolution of music.

This is the burthen of my song, this is the theme that runs through my melody—that music, in harmony with all of the processes of becoming in nature and art, becomes by minute increments—by growth. How, then, did music grow?

It has been assumed by writers that music has its origin and development in the innate appreciation of the human mind for the rhythms, melodies, harmonies and symphonies of nature, that it is the spontaneous outburst of the human soul in response to the music of the physical and animal world. The sighing of the winds, the murmur of the rills, the roaring of the cataracts, the dash of the waves on the shore, the singing of the forests, the melodies of birds, all these and many more have been considered as the teachers of music to man. The objective study of music among the lower tribes of mankind and among the various peoples of the world in different stages of culture, and of the history of music itself as developed by our own race, leads to a different conclusion.

Kids gambol among the rocks as if filled with joy, colts run about the pastures as if mad with ecstasy, cooing babes pommel vacuity and kick at void with hands and feet as pink and soft as petals of the rose, and seem delighted with the gift of newborn life; lads and lasses play in the park with shouts and laughter, as if existence was forever a May-day of sport.

There is pleasure in activity. The laboratory of life evolves a surplus of motion the expenditure of which gives rise to joyous emotions expressed in rollicking, boisterous play.

In youth and health and vigor, there is in the exercise of the muscles and the motions of the limbs a joy which may be heightened as many become associated in the same activities—brothers, sisters, cousins, sweethearts, wives, husbands, and parents. Let them unite in sportive activities and the very ecstasy of motion is produced. When such physical activities are systemized, the dance is organized. When a group of pleasure-seekers organize their activities

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in such a manner that the motion of every one is in harmony with the motion of every other one, the merry dance is an art and a social institution, and every one's joy is multiplied by every other one's joy. Then rhythm of motion becomes rhythm of emotion.

Man early learned that it was easier to control movements of dance by sound than by sight, and so he marked the rhythm of the dance by sounds of the voice or by sounds of the drum.

Blue-eyed children play with the brown-eyed, and brown-eyed children play with the black-eyed, and they all join hands and play "ring-around-a-rosy;" and out of this childish sport, by minute increments, musical rhythm becomes.

The first dancers were the men who lived in the forests, around the sheltered bays of the sea, on shores where quiet lakes mirrored the wild bird's flight, or on banks where the fishes sported in the wavelets of the brook.

The Eden of these sylvan men was large. It was walled with ice, so that men could not wander away to the north pole or to the south pole, but between these frozen regions the temperate and torrid lands were open. Before they learned to fashion stone knives, before they learned to use stone tomahawks, before they learned to use bone awls, before they learned to wear shell beads, before they learned to build shelters of boughs and bark and stone—while yet naked animals, men were found in every quarter of the globe. There were men on every shore, and there were men on the banks of every river. Sylvan men and women, boys and girls of the forest, dusky babes of the wood, were scattered throughout the whole habitable earth before the rudest human arts were invented, probably before organized languages were formed, and probably before institutions were organized. How do we know this is true? Is it the story of a romancer who finds the origin of the glacial drift in the lashing of a comet's tail? No, this conclusion is reached through the labors of an army of patient, earnest, keen-visioned investigators. They have found the birth-place of Art not alone in one land, but in all lands. The vestiges of the crudest arts are found everywhere and men began the career of artisans everywhere. It is found that men were already distributed throughout the world when they first began to use the simplest tools. Something more of interest is found. It is discovered that the time when the first art culture began was long ago—very long ago; not long when compared with the geologic history of the earth, but very long when

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compared with the book-recorded history of man. Archæologists have found vestiges of the beginnings of human art in geologic formations, and they have found them in all lands. So the "Garden of Eden" was all the world, and the sons of Adam were a host.

As time passed on from that ancient epoch when men had landed on every shore, they slowly, very slowly, improved in their arts. For later and still later geologic formations contain vestiges of higher and still higher arts, until at last men could make pottery and weave garments and cultivate the soil, and from that time on we have human industry recorded in books.

Early human history is recorded in the rocked-leaved bible of geology; late human history is recorded in paper-leaved books of libraries. Let us take up the story of music as a human art at the time when the late history commences, for that will serve our purposes.

All the sylvan people of the world rejoice in dancing. So far as we know, it was the earliest of the æsthetic arts, for we find it highly developed at the very birth of all other fine arts. This is because its foundation is laid in the physical constitution of man; it is the expression of the joy of animal life. These sylvan men danced by firelight, and forever they varied the rhythm of their dances with short steps and long steps, with steps to the right and steps to the left, with steps forward and steps backward; so dances come to be composed of a succession of varied steps, so rounded as to make a complete number in a figure of motion. A figure of motion, a complement of steps, is repeated over and over again and the voices of the dancers are trained to chant the rhythm to guide their feet in the dance. To mark the varied steps to each complement or theme of motion, the voice is varied; long notes and short notes are used, and then loud notes and soft notes; and yet there is nothing but rhythm. Then they begin to vary their voices as a guide to the moving feet by changing the vocal pitch, and the simple chant becomes. First, the voice varies only in time; then it varies in time and stress; then it varies in time and stress and pitch, and the chant is almost a melody. So the music of the lowliest men known to modern investigators is but rhythm. It is the universal music. All music in all times is based on rhythm, but some music has more than rhythm. The music of the savage has been improved. The sylvan man developed the first element of music to a high degree.

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At this stage the chant of unmeaning syllables undergoes change, for the emotions that are kindled by the dance are expressed in words — first, a few simple expressions of emotion — mere interjections — then exclamatory phrases, then exclamatory sentences, and the egg of poetry is laid.

This embryonic poetry is devoid of rhythm, for the rhythm yet belongs to the voice, not to the literature. The rhythm does not grow out of the words of the chant, but the rhythm of the chant is imposed on the words.

The stage of culture of this sylvan man is called *savagery;* and it is very long; and during all these centuries, and centuries of centuries, tribes of kindred men dance and chant. At the foot of the glaciers they have their homes, and walls of ice echo their chants; by mountain crags they have their homes, and the rocks echo their chants; in the valleys they have their homes, and the savannas are filled with their chants; in tropical forests they have their homes, and "the sounding aisles of the dim woods" ring with their chants.

When sentences are used to express emotions kindled by the dance, the leader repeats the words and the people chant the refrain, and more and more he gains a freedom in composition, and he varies his chant with new sentences, iterating and reiterating the emotional theme. In this way poetry becomes, and we have dancing-master poets and dance songs. As the dancing-master poet varies his theme of poetry so he varies his theme of music, and melody becomes. Poetry and melody are twins born of the dancing chant. Thus it is that "ring-around-a-rosy" becomes a song.

At first musical rhythm is an auxiliary of the dance — the rhythm of music and the rhythm of motion are partners. When unmeaning syllables are replaced by emotional words and sentences, music and poetry live together. Sometimes it is dancing and music only; sometimes it is dancing, music, and poetry altogether; sometimes it is music and poetry only.

So the grandchild of the dance and the child of the chant grows, and is emancipated from the control of dancing and becomes an art associated with poetry. Priests sing as they perform religious rites, women sing as they grind at the mill, children sing at their sports; and song, as rhythm and melody, exists during all the period denominated *barbarism*.

When freedom comes to song it starts on a new career. No

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longer chained to Terpsichorean feet, it soars into the realm of ideal emotion. The dance expresses the joy of exuberant life; the song expresses the joy of exuberant emotion. The dance carries the body through the merry maze; the song carries the soul on its way through the universe of thought.

If I would share my measure of joy with another, behold my measure is still full, and more than full — it overflows. When song comes, men find that though the solo is beautiful, the chorus is more beautiful, and rapidly choral music is developed. At the time to which we refer there is no harmony, but only rhythm and melody. Yet the egg of harmony is laid, for in melody sounds follow one another rapidly, and ere one note leaves the ear another joins it. The waning sound mingles with the waxing sound as the embryo of harmony. Thus melody trains the ear to the appreciation of harmony.

There is still another element of harmony in choral melody. The voices of a varied concourse of people are diverse in pitch. The notes of man are low and resonant like the voices of waves and winds; the notes of women are high and clear like the voices of birds; while children pipe like bees. In folk singing, groups of such voices unite and the elements of harmony are developed. The village life of barbarism when the people form a body of kin and kith promotes this rudimentary harmony, for they meet as one great family and join in many a festival that must ever lead to music and dancing.

And here another art assists in the development of music. The drama begins in savagery. The savage deifies the beast. To him the animals of the world are wonderful.

The eagle lives a life with which he cannot vie. It plays among the clouds, rests on the mountain tops, and soars down to circle over the waves of the sea. The humming bird poises over its blossom cup of nectar like a winged spirit of the rainbow. The deer bounds away through the forest and leaves the hunter lost in amazement. The squirrel climbs the tree and plays about among its branches, and springs from limb to limb and tree to tree, and laughs at the sport. The rattlesnake glides without feet over the rocks, and in his mouth the spirit of death is concealed. The trout lives in the water and flies up the brook as the hawk flies up the mountain. Dolphins play on the waves as children play on the grass. The spider spins a gossamer web; the grub is transformed

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into a winged beauty; the bee lays away stores of honey; the butterfly sports in the sunshine like a flower unchained from its stem. The air, the earth, and the waters are peopled with marvellous beings.

The folk-lore of the savage is a vast body of oral literature in which these wonderful animals are the principal actors, and his book of creation is the history of the animal gods. The stories of these animal gods are dramatized, and the priest-doctors of savagery are the actors who play before the people, assuming the parts of beast-gods. For this purpose they dress themselves in the skins of beasts, or wear masks that represent the forms and attributes of their deities. In recitations and dialogues, with much acting and mimicry, they represent the scenes of their mythology to the people. When poetry is born they re-cast their stories in poetic form, and chant and sing their verses.

Drama plays a great part in savage and barbaric life. In the tales of the drama the philosophy of the people is embodied. It contains their history of creation. The human mind is ever interested in the origin of things. The desire to know is the fundamental impulse of the intellect. The wisest and best of all peoples, even among the tribes of sylvan men, devote their highest intellectual powers to the enigmas of creation; and as opinions are formed, they seek to teach them to others. Thus it is in savagery and barbarism that philosophy is embodied in drama and taught to the people. In primitive society the drama is the school of religion, for there its precepts are taught, and its lessons are reflected in the theatrical mirror of life. The drama is deeply embedded in early culture, and is intimately associated with the intellectual growth of the race.

When the drama borrows aid from music, music itself is greatly invigorated. With the new impulse it rapidly develops, and this is the manner of its growth:

When the chorus is sung by skilled performers, the unskilled join in parts, adding a kind of refrain to the music, not by following the undulations of the melody in unison with the principal singers of the chorus, but by chanting on a note in harmony therewith; and thus harmony becomes.

To suit the conditions of the actors in the drama, harmonious parts are developed until one, two, or more accessory chants are produced; then these harmonious parts are developed from acces-

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sory chants to accessory melodies, more simple than the principal melody, which still retains the name.

In the music thus developed by our race there are usually four parts—soprano, contralto, tenore, and basso, and these are adjusted to four classes of voices.

Rhythm grows into melody and melody grows into harmony; yet music is young and music must grow, for it blossoms with the promise of becoming divine. Music is to become symphony. Harmony is a combination of coëxistent melodies; but symphony, in its broadest sense, is a combination of sequent harmonies. At the song stage of music, men begin to recite stories, simple dramas, and intersperse their narratives with stanzas of song; then the narratives are chanted, and songs and chants are combined, chants and songs alternating. At this stage a body of sacred music is developed. From hymns grow anthems, and bible passages are rendered in the solemnity of the chant and the majesty of the hymn, for chants and hymns alternate; and anthems by minute increments become oratorios, where bible history is taught in a succession of chants and hymns, changing along the course of the oratorio to express the varied emotions kindled by the sacred story. The mythic drama of the pagan world is represented by the oratorio of the Christian world.

The profane dramas that are recited and sung come to be chanted and sung with instrumental accompaniments. And then are produced the cantatas, or poetic stories set to music; and fugues, or musical dialogues, are composed; and nocturnes, serenade music laden with tender love. Then the cantata is developed into the opera as the drama is wholly set to music and the parts presented by *dramatis personæ*.

Men must laugh sometimes, for tragedy must be set in comedy, as precious stones are ofttimes set in filagree, and so the madrigal is developed, which is an elaborate musical composition of many parts designed for the expression of tender and hilarious joy in alternating movements; it is the comedy of music. And then comes the sonata, designed for solo instruments—a musical composition usually of three or more successive parts, each of which has a unity of its own, yet all so related as to form one varied and consistent whole. From the sonata, music passes to the symphony, which is a musical composition of successive parts having slightly varied but intimately related movements, treated in such a manner,

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by varying the time and stress and pitch, as to produce the greatest contrasts. With the anthem and oratorio, the cantata and the opera, the fugue and the madrigal, the sonata and the symphony, music has reached its highest stage in civilization.

The theme is the evolution of music, not the evolution of musical instruments, but something must be said of instruments, for they play an important part in the evolution of music itself. Were I to enter upon this theme fully, the task would be great. Then I should have to tell of thumpers of many kinds, by which the rhythm of the dance is controlled; I should have to tell of rattles by which the dance is enlivened; and I should have to tell of whistles, by which the dance is made merry with screams. Then I should have to tell how thumpers became drums, and how rattles became tambourines, and whistles became flutes; and I should have to tell how twanged flexible strings became violins, and how twanged rigid strings became pianos, and how bark whistles became horns, and how pipes became organs.

The invention of musical instruments begins with the sylvan man, who uses them to mark the rhythm of the dance. Throughout savagery and barbarism only time-marking instruments are invented. Not till civilization came to the people of the shores of the Mediterranean were instruments of melody produced; but when they appeared a new world of music burst upon the delighted ears of civilized man. Beaten instruments, reed instruments, wind instruments and stringed instruments give power and variety, and the capacity for musical production is marvellously increased. Men can sing solos, sing in chorus and sing in parts within the compass of the human voice; but with instruments they can play in unison with like instruments and in harmony with unlike instruments and with a compass far exceeding that of the voice. Then music is enriched by increasing the compass, it is enriched by increasing the volume, but more than all it is enriched by increasing the variety of its kinds. At this stage music is sweet, music is grand — but music must become sublime.

Instruments of music are but instruments of melody until science comes, when it is learned that sound is a mode of motion, and that low sounds are slow vibrations and high sounds quick vibrations. Then the knowledge comes by which man invents instruments of harmony, coëxistent harmony and sequent harmony.

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Thus science is the last great agency in the evolution of music, for it produces instruments by which symphonies become possible and music has reached the sublime.

As the blue egg becomes a robin, as the seed becomes a sequoyah, as the sands of the rill become an island, so "ring-around-a-rosy" becomes a symphony.

Feelings primarily arise from biotic pains and pleasures. It is one of the wonderful transformations of nature that the pain of a blow should slowly, through the years of human culture, develop into the sorrow for sin; that the pleasure of a feast should evolve by the metamorphosis of minute changes into the love of justice. How feelings develop into emotions and emotions into sentiments and sentiments into æsthetics is a long and beautiful story which cannot here be told. But the world is full of transformations. The metamorphoses of evolution have been the mysteries of time. In the solution of these mysteries men have been engaged through untold years — peering through their purblind primitive ignorance for more light, reasoning with guesses, philosophizing with myths and believing in errors, but gaining a little truth here and a little there until by minute increments science has been developed. The evolution of science is itself the mystery of mysteries, the metamorphosis of metamorphoses, for the germ of science is mythology.

With the development of intellect, the emotional nature of man by which he loves and hates has been evolved and the æsthetic pleasures have arisen under the law of mental association. By association with the joys of life music has been endowed with its power of producing emotion. This association must be explained.

I have spoken of the growth of music as a combination of sounds in succession and in harmony, as it is made by the human voice, and have alluded to the origin of the instruments by which parlor, orchestral and temple music is produced, but nothing has been said of the means by which music is endowed with its power to produce emotion. I have told of the body of music, but have said nothing of its soul. Music is freighted with joy and sadness, with hope and fear, with courage and cowardice, with glory and shame — it is freighted with all emotion; and how does the form of sound become informed with feeling?

When primitive man — poor, naked, houseless, savage man — lived in the Eden walled by ice and was scattered throughout the

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garden of the world, his capacities for pleasure were yet little developed. Still, he joyed much in his rude way. When the wind blew cold he warmed himself by the camp fire, and when the night was dark he illumined his home with fire-light, and about the fire he danced, and in the dance he had resource of joy. When the fisherman came home laden with a bounteous catch, he made merry by the fire-light dance; when the hunter brought in many pheasants or many antelopes, then, with kith and kin, he made merry by the fire-light dance; when the rich nuts fell from the trees in bounty he made merry by the fire-light dance; when the wind blew chill he drove the cold away by the camp-fire dance, and when the night was about him he rejoiced in dancing. So the nights of that region where the stars of the Great Bear are overhead, and the nights of that region where the stars of Orion are overhead, and the nights of that region where the Southern Cross is overhead, in all the habitable lands of the round earth — the nights were spent in dancing and the rhythm of the dance and chant became the language of these rude savage emotions.

But disease and wounds and pain and death were the heritage of this early man. Whence these evils came he knew not; why they came he could not tell. How they were to be driven away was the enigma of all savage thought. Through an illogical philosophy, the origin of which is a long and strange story, he came to believe that diseases were living beings; that toothache is the pain wrought by the gnawing mythic worms; that the cough is caused by mythic insects; that headache is caused by invisible mythic ants; and that all diseases and all pains are produced by these mythic agencies. And he tried to drive them away by shrill shrieks, by mad howling and by horrid imprecation. Then he sought to gain the aid of the friendly spirits of the world — the good mythic beings. To him the rhythm of the dance and the chant was the language of joy; so he sought to woo these friendly spirits by using this language of joy, and when wearied with his own efforts at driving away the maleficent spirits, he turned to the dance and the chant, and with them called for the beneficent spirits. In this manner the sylvan man came gradually to believe in the direct efficacy of dance and music as a medicinal agency. Dance and music are the quinine and calomel of the savage — the "water cure," the "faith cure," the "blue glass cure," the "mind cure," the "Christian science cure," the "youth-restoring elixir," the panacea for all human ills.

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When the poor diseased people recovered, the joy of recovery became associated with music. The welcome to health and companionship which the poor invalid received was given in dance and music.

Sometimes storms came and destroyed their rude houses; sometimes drought came and destroyed their harvests; sometimes fierce winds came and congealed their life-fluids; sometimes mad lightning came, and, shivering the trees, ended their lives. And so by flood and wind and lightning and many other agencies, they believed themselves to be persecuted by the spirits of the animal gods who must be appeased; and what would please the god so much as music and dancing? And so they danced to their gods and beat their drums to their gods and played their whistles to their gods and blew their horns to their gods, until the winds stilled and the storms abated and the lightnings went out and the thunders hushed and the floods ran away to the sea, and then they rejoiced with feasting and dancing and music.

Before the sylvan man had learned to plant fields and build storehouses and provide for future days, he believed that every thing was the gift of his animal gods. The earliest provision that mankind made for the future was to lay up a store of their good will. And how could he gain their good will but by dancing and music? So at new moons and at new seasons he held festivals in honor of his gods and gave them dancing and music.

When in a later culture man gathered the fruits of the forest and mead as a store for the winter day and planted fields and gathered grains, he made thanksgiving to his gods in dancing and music.

The rallying cry to war was dancing and music. There is an instrument used by savages in many lands that consists of a simple tablet of wood, a hand's breadth in length and a finger's breadth in width, to which a short string is attached by one end while the other is fixed to a stick like a cane. The performer holding the stick in his hand, whips the tablet of wood through the air in such a manner that it makes a sound, sometimes quick but low, like the whiz of a bullet on the battle-field, sometimes shrill and loud, like the shriek of a cannon-ball thrown into a bombarded city. With these instruments a group of naked savage warriors, intent on plunder, rapine and the midnight murder of men, women and children, gather about the camp-fire in the weird dance, and leap and howl and whip their bull-roarers until they work themselves into a state of fury.

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It was in this manner that the music was freighted with emotion by the sylvan man when it was only rhythm, and when it was chained to the dance.

Some music expressed in rhythm and melody has had a long life among all the barbaric and civilized peoples of the world. Minstrels have carried it about; men have sung their songs in field and forest; women have sung their songs at the oven and the loom; boys have sung their songs while driving the herds to pasture, and girls while milking cows; and there are songs for all times and all conditions and all peoples. Song has ever remained as folk-music, the delight of the people.

There are songs celebrating all passions — all joys and all sorrows, all hopes and all fears, all loves and all hates. All the emotions of the human soul are coined into song. Song is the reservoir into which all human feelings are poured, and it is the fountain from which all human feelings may be drawn. And this is true not only in our language, but in all languages.

When harmony was given to music through its association with the drama, musical compositions were no longer confined to simple songs for the field, the fireside, and the chapel, but great pieces were composed for the temple and theatre, and music was made to express the emotions of religion and romance, as in the oratorio, cantata and opera. This music bore on its wings the hope of heaven and the fear of hell. It told of the joy of the angels before the throne of God, and of the torments of demons in the presence of the Devil. The profane music of this period related biographies and histories filled with love and revenge, virtue and crime, courage and cowardice, repose and tragedy. Music in this stage is freighted with the feelings that are kindled and expressed by laughter and crying, by prattle and wrangling, by caresses and blows, by kisses and frowns, by praise and reproof, by plenty and poverty, by strength and weakness, by health and disease, by birth and death, by festivals and funerals, by carnivals and battles, by peace and war, by victory and defeat, by justice and injustice.

And now we must speak of the symphonic stage of music, when science has given it a multitude of sweet instruments.

The art of music was not born of the music of Nature; it was born of the pains and pleasures, the joys and sorrows of mankind.

The appreciation of the beauties of nature is of slow growth, and

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it is only in civilization, and with the most cultured people of civilization, that these beauties are sources of joy, and it is only in the latest music that the highest intellectual pleasures are expressed. The beauties of the earth, the sea and the air, and the sublime spectacle of the heavens are gradually being wrought into the emotional nature of mankind, and the new music is informed with the strains that are played by Old Ocean against the shores of every land. It is filled with the anthem-music of the forest and the songs of the birds that chorus the round earth with the rising sun.

In its late history new attributes have been added from the contemplation of nature. These are feelings kindled by the higher intellectual activities. The human reason has acquired a knowledge of the universe and derived exalted emotions therefrom. The boundless sea now tells its story. From arctic and antarctic lands navies of icebergs forever sail, to be defeated and overwhelmed by the hot winds of the tropics. The lands with happy valleys and majestic mountains rise from the sea, built by the waves and fashioned by fire and storm. Over all rests the ambient air, moving gently in breezes, rushing madly in winds, and hurling its storms against the hills and mountains of the sea and the hills and mountains of the land.

The land, the sea and the air are the home of a world of life, which man studies with ever-increasing interest and pleasure. The solid earth is composed of crystalline forms and exhibits chemical activities which ever challenge admiration. Sound and heat and light and electricity and vitality and mentality present modes of motion the contemplation of which fills the mind with delight. Looking above the earth the worlds of the universe are presented to view, and their wonders fill the soul. So music has come to be the language of the emotions kindled by the glories of the universe.

Thus is seen the growth of music in four stages: music as rhythm, music as melody, music as harmony, and music as symphony. Rhythm was born of the dance, melody was born of poetry, harmony was born of drama, symphony was born of science. The motive of rhythmic music was biotic exaltation; the motive of melody was social exaltation; the motive of harmony was religious exaltation; the motive of symphony is æsthetic exaltation. It is thus seen that music develops from the emotional nature of man,

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as philosophy has its spring in the intellectual nature. The earliest emotions arose from the biotic constitution,— simple pleasure or pain, as felt in the body and expressed in rhythm; they were mere feelings. Then feelings were idealized and became emotions and were expressed in melody; then the emotions were idealized and became sentiments and were expressed in harmony; then the sentiments were idealized and became intellectual conceptions of the beautiful, the true and the good, and these were expressed in symphony.

Is there a new music for the future? The science of music answers "Yes." We know that music has been chained to "form" and imprisoned in the Bastile of musical intervals and guarded by the henchmen of mathematical dogmas. But a few great musical composers, like Wagner, have broken the chains and burst the bars and killed the jailers, and they sing their liberty in strains of transcendent music.

When it is desired to cultivate skill in musical performance, it is necessary to cultivate the art in the individual in the same order in which it is cultivated in the race; and he must first master rhythm, then melody, then harmony, then symphony. Then the love for music must be acquired in the same order. No one can love a symphony or an opera who does not first love song. If you would love the higher music, you must love the songs of the people; and to affirm that you love a symphony or an opera or a cantata, but that you do not love a song, is like averring that you love a garden but do not love a rose, that you love a bouquet, but care not for a lily; for a symphony is indeed but a bouquet of melodies, and an opera is a garden of many flowers.

Happy is the home that is filled with song, where boys and girls sing the melodies of the people, and where they make these melodies more musical with the violin, the piano or the flute; for to music is consigned the purest joy.

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REPORTS OF COMMITTEES.

Report of the Committee on Indexing Chemical Literature.

The Committee on Indexing Chemical Literature respectfully presents to the Chemical Section its seventh annual report.

During the year just closed three bibliographies have been published by the Smithsonian Institution.

A Table of Specific Gravity for Solids and Liquids. The Constants of Nature, Part I (new edition, revised and enlarged). By Frank Wigglesworth Clarke. Washington, D. C., 1888. Smithsonian Miscellaneous Collections No. 659. 8vo, pp. xi, 409.

This volume contains the specific gravities of 5,227 distinct substances and 14,465 separate determinations, being more than twice as many as in the first edition with supplement.

Index to the Literature of Columbium, 1801–1887. By Frank W. Traphagen. Smithsonian Miscellaneous Collections No. 663. Washington, 1888. 8vo, pp. [iv], 27.

This Index contains the threefold arrangement chronological, alphabetical by authors, and subject-matter. The abbreviations of Journal-titles are those adopted by the Committee on Indexing Chemical Literature upon whose recommendation this Index was printed.

A Bibliography of Chemistry for the year 1887 by H. Carrington Bolton. Washington, 1888. Smithsonian Miscellaneous Collections No. 665. 8vo, p. 13.

Prof. Wm. L. Dudley, Vice President of the Chemical Section of the A. A. A. S., has appended to his address on the Nature of Amalgams an Index to the Literature of the subject which will be printed in the forthcoming volume of the Proceedings of the Toronto meeting.

We record the publication of the following index. Lists of patents relating to Soap and Candles in "Manufacture of Soap and Candles" by Wm. Brannt, Philadelphia, 1889.

Also:—An Index of Researches upon the Production of Ammonia from Atmospheric Nitrogen. By Ezra J. Ware. Published in Proceedings Michigan State Pharmaceutical Association, 1888, H. J. Brown, Ann Arbor, Mich., Secretary.

Reports of progress from several volunteer indexers have been

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received. Dr. Alfred Tuckerman has completed his Index to the Literature of Thermodynamics except a subject-index to which he is putting finishing touches. He has also begun an Index to the Literature of the Chemical Action of Light, a subject suggested by the Chairman of your Committee.

The publication of this annual report is always followed by numerous applications for information, especially with respect to the method of indexing adopted by the Committee. These inquiries we may in some degree anticipate by repeating the statement that this Committee does not prescribe any standard, nor dictate any system for volunteers to follow. Those interested in the work of the Committee would do well to examine the six reports already published, in which will be found suggestions for systematic indexing (1885), a complete list of indexes already printed under the auspices of the Committee (1887), and a list of "Abbreviations of Titles of Chemical Journals," intended to secure uniformity in references (1887).

The choice of subjects for indexing has generally been made by the volunteers themselves; in a few instances only the topics have been suggested by the committee, at the request of co-workers. These subjects, as shown in our reports, cover a wide range in physical, inorganic and organic chemistry; the desirability of procuring indexes to individual elementary substances should not be overlooked by those who contemplate offering aid. A few copies of the Report of 1887 (which includes lists as above) remain, and can be had on application to the chairman, to whom also letters of inquiry may be addressed care of Smithsonian Institution, Washington.

H. Carrington Bolton, *Chairman*,
F. W. Clarke,
A. R. Leeds (in Europe),
A. A. Julien,
John W. Langley,
Albert B. Prescott,
Chas. K. Wead.

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Report of the Committee on the International Congress of Geologists.

Since the last meeting of the A. A. A. S. the London Congress has been held, at which a fair representation of American geologists was present. The reports of the American Committee having been approved by the unanimous vote of Section E at the New York meeting of the A. A. A. S. were, with a few additions (not obtainable for that meeting but unanimously approved by the committee) presented to the Congress and distributed among its members.

Mr. Topley, the General Secretary, ordered a large edition of the American volume, with pagination altered to suit the needs of the volume of the Congress which he was editing.

It has been decided to issue the geological map of Europe in instalments of one or more of the sheets at a time, instead of waiting until the whole map is complete, and this has rendered it necessary to make special arrangements for the delivery of these sheets to the American subscribers who now number the one hundred required to make up the sum paid by the "large countries." Unfortunately the undersigned has not received any response to the letters addressed to Mr. Hanchecorne of the Executive Committee on the map, and is therefore unable to propose a plan of distribution.

The London Congress decided that the next session should be held in Philadelphia, Pennsylvania, United States, and appointed a provisional committee to take such action as might appear best to provide for the session. This committee appointed a larger committee, of which Dr. Newberry is chairman.

Your committee reports progress and asks to be continued.

James Hall, *Chairman*,
Persifor Frazer, *Secretary*.

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Report of the Committee on Anatomical Nomenclature, with special reference to the Brain.

During the past year, some of the members of the Committee have given to the subject intrusted to them as much time as their regular duties would permit. They agree upon one point, viz., the advantages, other things being equal, of *mononyms* (single word terms) over polyonyms (terms consisting of two or more words). Before making specific recommendations or presenting a final report, the Committee think it advisable that they and other anatomists should have an opportunity of discussing at leisure the simplified nomenclature which they are informed is employed in certain treatises which will be published during the coming winter. They therefore ask to be continued.

Burt G. Wilder, *Chairman*,
Harrison Allen,
Frank Baker,
Henry F. Osborn,
T. B. Stowell.

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Report of the Committee of Section C, on Methods of Analyses of Waters and Statement of Results.

Your Committee offer the following report:

1. That in the course of the year 1887–8 a scheme for stating the results of the analyses of waters, both the so-called mineral waters, and waters used for drinking, was widely distributed to all chemists in this country supposed to be specially interested in the subject, with request for comments, suggestions or reasons for disapproval. This scheme was also printed in the Journal of Analytical Chemistry, and came thus to be still more widely brought to the notice of chemists.

Not half a dozen replies to the circular were received, and chemists most widely known as water analysts were conspicuously wanting, even in this small number.

So far as noticed, the scheme received but little favor, and especially that part of it referring to mineral waters; less objection was taken to the other part, for potable waters, and a uniform method of stating results in parts per million appeared to be more generally acceptable.

In view of the want of interest in this matter on the part of chemists, and especially of those most interested in water analysis, your committee has hesitated somewhat to present any recommendation in regard to it but, nevertheless, offers the following for your consideration.

That in the case of the usual examination of a potable water for sanitary purposes, *all results be stated in parts per million.*

2. That beside giving parts of ammonia, free and albuminoid, and nitrous and nitric acids, there be given also parts of nitrogen as ammonia, free and albuminoid, and as nitrous and as nitric acid: the latter alternative being taken with a view to the ultimate use of this method alone.

With regard to mineral waters your committee has no recommendation to offer.

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At the preceding meeting of this Section, your committee was directed to take into consideration also the unification of details of the method of the sanitary examination of water, especially as to the determination of the organic matter, and the nitrogen compounds.

In April of this year a series of questions was sent to the prominent water analysts in the country, or such as were known by the various members of the committee to be so interested, for the purpose of eliciting information as to the methods pursued by them; it being the opinion of your committee that, whatever the course of examination to be recommended for general use, it will be the more likely to meet with the desired adoption, the more it is in accord with the methods followed by those who have had most experience in this work. By the kindness of the editor of the Journal of Analytical Chemistry, a copy of these questions was sent to every subscriber of that Journal in advance of their appearance in the Journal itself.

These questions, together with the introductory explanations, were as follows:

DEAR SIR:

At the last meeting of the American Association for the Advancement of Science the Committee of Section C, on methods of stating the results of water analysis, was continued, and it was directed, further, to ascertain and report what can be accomplished towards securing on the part of water analysts uniformity in the methods of examining water used for drinking, and especially as to the organic matter.

It was the decided opinion of the meeting at which this action was taken, that a very great advantage would be gained, in respect to the sanitary study of waters, if at least a certain part of the chemical examination should be conducted on a common plan.

In consideration of the great and increasing importance of this sanitary question, and the more and more prominent position that the chemist is coming to occupy in the consideration of the question, and of the very evident fact that these methods of examination for organic matter, etc., are often not based on sharp and well defined reactions, making it altogether likely, if indeed not almost inevitable that different results should be obtained with different management of the details of the operations concerned; considering also the evident desirability that the confidence of the public in the judgment of the chemists should not be weakened by differences among the chemists themselves, we trust that you will be disposed to join in this movement by coöperating with this committee, and to give such time to the matter now as may be necessary for the answering of the accompanying questions, so far as your own practice leads you to take a practical interest in the subject.

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THE COMBUSTION METHOD.

1. Do you use the Frankland combustion process, and if so, does your experience lead you to believe that its general adoption would lead to more useful and concordant results than are obtained by other methods in common use?

THE WANKLYN METHOD.

2. Assuming that you use this method, do you follow it precisely as described in the latest edition of Wanklyn's work on water analysis (1889)?

3. Referring to Mallet's paper in the Annual Report of the U. S. Board of Health, 1882; and assuming it to be allowed that the process as described by Wanklyn may be improved:

Would you not favor the adoption by general consent of the following suggestions made by him on page 208, based as they are on the results of his very extended investigations?

a. "In order to avoid uncertain ending of the collection of ammonia, whether free or albuminoid, stop the distillation when, and not before, the last measure of distillate contains less than a certain proportion—say 1%, — of the whole quantity already collected. This would in many cases involve the necessity of replenishing the contents of the retort with ammonia-free water."

b. "In order to diminish the loss of amines or other volatile forms of nitrogenous matter, a separate distillation should be made with alkaline permanganate added *at once*, in addition to the usual course of treatment prescribed by Wanklyn — distillation begun with Na_2CO_3, and continued after the addition of $KMnO_4$; the results of the two distillations should be compared."

c. "In reporting the results obtained by the albuminoid ammonia process including the determination of free ammonia, the details of the evolution of ammonia, as collected by separate measures of distillate, should always be given."

3. Or in the place of *a* would you favor the adoption of Professor Breneman's proposal (Jour. Am. Chem. Soc., 8, p. 227) to collect a uniform number of portions of 10 cc. each, supposing that you follow the 100 cc. modification, four portions for the free ammonia, and seven for the albuminoid?

4. Would you favor for general adoption the recommendations of Professor Breneman (*loc. cit.*) of a uniform rate of distillation, namely 10 cc. per ten minutes?

5. In the preparation of your permanganate solution do you follow Wanklyn or Mallet, *loc. cit.*, p. 279?

6. Do you follow the 500 or the 100 cc. plan as given by Wanklyn?

7. Will you kindly describe and give reasons for any modifications of the "ammonia" process as described by Wanklyn that you have introduced in your own practice, and that you consider of sufficient importance for general adoption.

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OXYGEN CONSUMED.

8. Do you follow Wanklyn, Tidy or Kubel?

9. Assuming that, of course, you would prefer for general adoption the method that you follow: would you kindly give for incorporation in our report a brief statement of the reasons for your preference, and for important objections to the other methods?

10. Please describe and give reasons for any modifications of the process followed, that you have introduced in your own practice, that appear to you to be of sufficient importance for general adoption.

11. Do you regard the estimation of oxidized N. compounds as of sufficient importance for general adoption?

12. If yes, do you estimate them separately or together?

13. Will you please name the methods employed for these estimations, with reference to the place where they are described, and describe such modifications of the methods thus described as you have introduced in your own practice, and which appear to be of sufficient importance to be recommended for general adoption.

BIOLOGICAL EXAMINATION.

14. Do you make any use of biological examination of waters? Does your experience lead you to regard it as practicable and important for general adoption?

To our regret only seven communications were received in reply to this circular, and some of the most prominent water analysts addressed failed to respond. On the other hand, very full and instructive and satisfactory replies were sent to us by a few who have had large experience in this line of work.

The general tenor of these replies is as follows:

1. No one uses the Frankland process.

2. While all follow the principle introduced some years ago by Wanklyn, Chapman and Smith, not one follows the method in detail as now described by Wanklyn in either of the editions of his work. It is Mallet that is followed in this country rather than Wanklyn.

3. Nearly all distil till the ammonia, both free and albuminoid, is completely expelled, or at least go so far as Mallet suggests, the one per cent limit.

b. No one favors this suggestion, although some take account of it indirectly in their modes of operation.

c. Some consider this of great importance, others of none, but the suggestion is favored by a large majority.

4. A uniform rate of distillation, and at about the rate of $\frac{1}{10}$ of

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the whole quantity taken in ten minutes is almost unanimously favored.

5. Nearly all follow Mallet.

6. Nearly all take 500 cc.

8. Kubel's method is followed in principle, so far as any determination of oxygen consumed is made. Opinions as to the value of this determination are about equally divided, for and against.

11. Almost universally, yes, and especially by those whose opinions would naturally be regarded as the most weighty.

12. Usually together, unless the qualitative test for nitrites indicates such a large proportion as to seem to make a separate determination advisable.

13. For nitrates and nitrites together, three use the copper-zinc couple, one the acid-phenyl sulphate colorimetric method, and one reduces by aluminum, and estimates the ammonia; the others did not report the methods followed. For nitrites all that report any method, four in number, use the Griess method.

14. Unanimously, no, either because it is believed to be as yet uncertain in its indications, or because they have had no experience with it.

Your committee feel that if this summary represented the practice and opinions of a large number of chemists of reputation, including at least most of the prominent water analysts, and the recommendations that follow were based on such a fairly representative summary, a long step might be taken in the unification of the details of the examination of water with reference to its fitness for domestic use.

But under the circumstances it seems to them wise, while not yet relinquishing the undertaking, to move deliberately, and to recommend a course of procedure for the examination of such waters, only for provisional adoption, which shall be printed and distributed as soon as practicable, trusting that a wider interest may yet be awakened in the matter, and many more communications be sent in for the consideration of a future meeting.

On this understanding the following course of examination of a water, for the estimation of its nitrogen compounds and organic matter, is recommended. It is based essentially on the recommendations of Mallet and Smart, as given in the Report of the National Board of Health for 1882, and is in the main in accord with the best practice in this country, so far as we can learn what that prac-

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tice is. Full details of the course are given here only when they are essentially different from those given by Wanklyn in his latest work on water analysis.

The reagents:—The solution of *sodium carbonate* must itself be tested for ammonia, even though made with freshly heated salt and ammonia-free water.

For the solution of *alkaline potassium permanganate*, dissolve the usual quantities of these reagents (8 grams of $KMnO_4$ and 200 grams of KOH) in 1250 cc. of water and then boil down to 1000 cc.

For the *Nessler reagent* follow Mallet-Smart (*loc. cit.*, p. 279).

For the standard solution of *ammonium chloride*, dissolve the salt in ammonia-free water.

The apparatus:— The neck of the retort is to be drawn out so that it will pass for the distance of one or two inches into the condenser, and a tight connection is to be made between the two by means of rubber tubing slipped over them, or by means of a rubber cork. If a flask is used instead of a retort, the connection between the tube from the flask and the condenser is to be made in a similar manner.

The process:—200 (or 40)[1] cc. of distilled water are put into the retort or flask of suitable size, with 10 (or 2) cc. of solution of sodium carbonate, the water is boiled down to about 100 (or 20) cc. and the last portion of 50 (or 10) cc. is nesslerized. If not free from ammonia, more water must be added and the boiling repeated till no appreciable amount of ammonia is contained in the last 50 (or 10) cc. of distillate.

Then 500 (or 100) cc. of the water to be examined are added, and the distillation and nesslerizing are conducted as described by Mallet-Sharp (*loc. cit.*, p. 280), the rate of boiling being so regulated that very nearly 50 (or 10) cc. of distillate will be collected in each succeeding ten minutes.

For the *total* ammonia a second retort or flask is cleaned in the same manner as above described, except that 50 (or 10) cc. of alkaline potassium permanganate are added, instead of the sodium carbonate. Another portion of 500 (or 100) cc. of the water is added, and the distillation and nesslerizing conducted in the manner above indicated.

[1] The figures in parentheses indicate the quantities to be taken in case the 100 cc. modification of the method is followed.

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e subtraction of the *free* ammonia of the first operation from *tal* ammonia of the second gives the albuminoid ammonia.
nesslerizing, five minutes are to be allowed for the full de-nent of the color.
e details of the evolution of ammonia in the several distillates be recorded.
s of ammonia from imperfect condensation being easily pos-this should be reduced to a minimum by the use of as free a of condensing water, and of as low a temperature, as prac-e.
this ammonia work is to be done in a room free from any nination of the air with ammonia, and if possible in a special set apart for it.
gen consumed:—Kubel's method as given by Smart (*loc. cit.*,) is to be followed.
dized nitrogen compounds:—Nitrates and nitrites together are determined by the copper-zinc couple. Nitrites are to be de-ed by the Griess method Tanner (*loc. cit.*, p. 280).

mists everywhere are recognizing the importance, in public of uniformity in the methods of analysis followed; in no y has more been accomplished in the unification of methods n our own, particularly under the auspices of the Association icial Agricultural Chemists. No one can read the history of work without realizing the necessity that it should have been and its value.
ch of that work refers to processes of analyses that would much less liable to variation in results in different hands, would be the case with the processes that we use in sanitary analysis. One of us being this year in charge of a portion t work, the analysis of cattle foods, he may be allowed to an illustration of this point from the results received, the tion being such a simple one as the determination of the ether-t. The sample of hay was prepared in large quantity, in y ground condition and most carefully mixed, and sent in ns to each of the sixteen experiment station chemists who teered to take part in the work: the results, calculated to dry nce, ranged from 2.66 to 7.10. All the analysts were sup-to work by the same method and with precisely similar re-s, for which full directions were given; but their reports

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of the details showed that at least in some respects these details were not everywhere alike. This is, to be sure, an extreme case; but if other discrepancies are not so great, there are still far too many of them that are discouragingly large, and for the elimination of which more work must be done before the Association can consider its work on the analysis of cattle foods as finished.

Public analytical work is done by chemists of all degrees of training, skill and experience, and differences in results may be due to this to some extent, how large it is difficult to decide; but it seems reasonable to suppose that these differences will be materially lessened, if the methods of analysis followed are the same in detail, provided, of course, that the methods are as reliable as they can be made. Some of the most important of this analytical work in the sanitary examination of water is confessedly not sharp in respect to the reactions involved, and for this reason uniformity in the management of the details would seem to be so much the more an urgent necessity.

Your committee trust therefore that the course here recommended will so far meet the approval of water analysts, non-members as well as members of this Association, that, for the reasons mentioned above, they will be ready to follow its details, at least on trial as a provisional arrangement, in their own work.

In conclusion, we would refer to the interesting results obtained by Professor Drown in the application of the Kjeldahl method for nitrogen to the sanitary examination of water as seemingly full of promise of sharper results than any that can be obtained by the Wanklyn process, and well worthy of careful comparison with that.[1]

G. C. CALDWELL,
J. W. LANGLEY,
J. A. MYERS,
W. H. SEAMAN,
R. B. WARDER.

[1] Prof. W. P. Mason, a member of the Committee, is in Europe at the time of presenting this Report, and has had no opportunity to see it.

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Report of the Committee of Conference on the Organization of a National Chemical Society.

Your Committee report that they have been in consultation with committees of conference appointed by (1) The Society of Official Agricultural Chemists, (2) The American Chemical Society holding meetings in New York, (3) The Washington Chemical Society, and (4) The Chemical Section of the Franklin Institute. Also they have consulted with a number of the best known chemists in several sections of the country, and have conversed on the subject of the proposed society, with those engaged in chemistry, here and there, as opportunity has permitted.

1. The census of opinion.

The four committees of conference, without dissent declare their conviction that the organization of a society of American chemists is most desirable, and already feasible. The individual chemists, almost without exception, express their belief that the Society proposed, if strong enough for healthful life, would be of much advantage. On the question of the feasibility of the society as an organization of strength and credit the individual chemists consulted have been divided in opinion. Those who doubt the practicability of the organization, or deny it, do so upon the following named grounds: (1) The annual meetings could not have good attendance because distances in this country prevent it. (2) A hearty coöperation of chemists is clogged by local prejudices and by apathy. (3) Efforts for satisfactory organization in the past have met with failure. (4) Societies in this country find a level below that of the best research. (5) A new society would be liable to add a new journal, while there ought rather to be consolidation of existing journals. (6) An independent society as proposed would weaken Section C. Those who affirm the feasibility of a good society of American Chemists set forth reasons as follows: (*a*) Notwithstanding separation of chemists by American distances we have one centre where they come together, and more and more must come, and this is the annual meeting of the American Association for Advancement of Science. (*b*) Neither apathy nor local prejudice can very

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long prevent a large body of American specialists from organizing a distinctive union. (*c*) The past is not the pattern of the future in respect to chemistry in this country. (*d*) Societies of scientific work have been found not to weaken true research, but rather to extend its inspiration. (*e*) A healthful society would serve to consolidate periodical literature, and this is to be the specific effort of the Society to be formed. (*f*) With the safeguards to be set by this Association, Section C will gain strength by coördination with the new society. The local sections will serve as feeders, bringing the strength of the specialists, in an independent organization of clear-cut character, into alliance with the American Association in all its breadth and liberality, for mutual advantage.

2. The time for organization.

Upon a full canvass of the situation your committee have been convinced that the time is coming for a society of American chemists. That the time has now come your committee are not prepared to say, but they submit that the time will come whenever the working chemists will heartily unite in the organization.

3. Coördination with the A. A. A. S. is indispensable.

There is but one centre accessible enough and attractive enough for the annual meetings of the new society, and this centre, not always in the United States, is *always the meeting of the American Association*. To organize for further union, chemists must cherish the growing chemical aggregation in Section C, now of permanent standing and great social advantage, and an alliance with this Section, carefully framed for *mutual* benefit, must be fundamental in the new organization.

4. Consolidation of chemical periodicals.

Beside the journals of distinctive credit there is in the United States and the Canadas a wide range of fragmentary chemical literature of periodical issue, often interrupted, yet of permanent value. From the work of the various academies of science, and from the reports of the various bureaus of science in civil service, the agricultural stations and commissions, the boards of health, the government surveys, geological and metallurgical commissions and associations, the patent office, the chemical service of the great corporations, railroads, mines and manufactures, — from all these, every year, a considerable body of original literature in pure and applied chemistry ought to be gleaned and made accessible to the world. Especially is this true of chemical technology. The industrial

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chemistry of this country is original, and full of value both to industrial art and to pure science, while as a rule an American chemist can find in literature the technology of every civilized country except his own. It should be the duty of a publication representing a society of American chemists to summarize the noteworthy chemical results of all the American workers. For the most part, abstracts instead of full memoirs should be given. Moreover, it should be the distinct purpose of the new society, so far as possible, to favor consolidation with the established periodicals of distinct credit in this country. Your committee beg leave to recommend a wise and liberal policy, to this end, with all reasonable concessions at the beginning, so that the expenses of the needed journals shall be made as low as possible to subscribers. And it seems to this committee inadvisable to engage in that publication of abstracts of all current chemistry, now done so well and in such vast proportions by European publications which active chemists must keep at hand. With a true policy of public helpfulness, a society of real national proportions in hearty working unity must promote consolidation of periodical literature, as a fragmentary society must hinder the same.

5. A society should not go forward without an assured basis.

A sufficient membership ought to be pledged, upon a provisional plan of organization, in representation of the entire country, before the society should take date as an independent body. Until the membership reaches a sufficient number, to be designated by this Association, let the constitution of the society remain an unfulfilled proposal of Section C.

6. An order of procedure.

Whenever the Chemical Section and the Council may decide that the time has come for provisional organization, it is recommended that the Section do then nominate and the Association appoint a Committee of Organization of a Society of American Chemists: to frame constitution and by-laws, to address chemists, and obtain pledges of membership. The committee to be bound by certain instructions to be framed by this Association. The membership of the committee as nominated by Section C, to include representatives of the Society of Official Agricultural Chemists, the American Chemical Society holding meetings in New York, the Washington Chemical Society, and the Chemical Section of the Franklin Institute; and the committee to have power to add to its membership

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from chemists of appointment by local societies, provided that the appointees of this Association remain a majority of the voting members of the committee. And that the American Chemical Society holding meetings in New York be invited to submit its constitution and operative laws for the use of the committee, also to yield its name to the new society, and to go forward as the New York Section of the American Chemical Society, retaining under its corporate control as a section the property and vested rights it now holds.

ALBERT B. PRESCOTT,
ALFRED SPRINGER,
EDWARD HART.

REPORT OF THE COMMITTEE ON CHEMISTRY TEACHING.

THE Committee regret to say that one of their number, Prof. W. A. Noyes, was absent in Europe the entire year and therefore could not give personal attention to this report.

In presenting their report and asking to be discharged from the further consideration of the subject, the Committee beg to say, that so much has been written bearing on the matter committed to them, that they felt it unnecessary to enlarge as much as would have been desirable, if their report was the first of its kind.

They endeavored to give some testimony not found in the other reports and to add the influence of the Chemical Section in favor of the increasing public interest in and attention to science teaching in general and chemistry in particular.

Among the publications alluded to, deserving especial attention in this connection, are:

Circular No. 6 of the Bureau of Education U. S., on Teaching of Chemistry and Physics in the U. S. F. W. Clarke. 1880.

Report on Science in Schools, American Society of Naturalists, 1888.

Report of the National Educational Association, 1887.

Report of the Committee on Physics Teaching to A. A. A. S., 1888.

Report of the Committee of the British Association for the Advancement of Science, on Chemistry Teaching, Bath Meeting, 1888

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The science of chemistry is of very recent growth and has but lately received consideration in arranging courses of high-school studies.

The first collegiate chair of chemistry in this country was established at Princeton in 1795. In 1824 the Rensselaer Polytechnic Institute was opened, the first of the technical schools now so numerous, in which chemistry holds an important place. In 1838, Charles T. Jackson, of Boston, opened his laboratory for practical instruction, perhaps the first instance of its kind among us.[1]

As regards the popular estimate of its value as a part of education, statistics show that, while the number of students taking classical courses barely keeps pace with the increase of population, the number selecting scientific courses, in most of which chemistry holds a prominent place, increases more rapidly than the increase of population, and that chemistry and cognate branches are year by year added in larger proportions to the regular college courses.

This progress is perfectly rational. A science which treats of the constitution of matter itself is entitled to particular attention as a part of the foundation of all correct reasoning about the marvellous transformations of matter that form a distinguishing feature of our modern civilization. And since its laws and principles require special training to be understood, it seems particularly needful that every rational scheme of public instruction should give due prominence to this science.

Chemistry and the other natural sciences are as efficient for mental discipline, as valuable for educating the judgment, and as useful a preparation for the practical duties of life, as language or mathematics.

The Committee began their work by formulating the following questions:

1. At what time should the teaching of chemistry begin?
2. How much time should be given chemistry before and in the high school?
3. The best methods of teaching in the grammar school?
4. The best methods of teaching in the high school?

We believe that very young children may be profitably interested in a few simple lessons on the common chemical phenomena of our daily life. In our opinion, public school teachers should be re-

[1] In Scientific American of June 9, 1888, will be found a sketch of the life of Professor Booth of Philadelphia, by Marcus Benjamin, from which it appears that Professor Booth opened his laboratory in 1836 for instructions in chemistry.

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quired to have such an elementary knowledge of chemistry as would enable them, even in the primary grades, to impart accurate information regarding the constitution of air, water, foods, etc., and to explain the nature of combustion and other common chemical processes, and that they ought also to be able to perform a few simple and inexpensive experiments.

As the public schools are not intended to give special instruction, but to lay such a foundation of general culture as is best adapted under the given conditions to meet the wants of all classes of the community, every study scheme, in our opinion, should start from a careful decision as to the division of time between the leading branches of learning, considered in classes, for example: language, mathematics, chemistry and physics, biology, understanding by biology all branches relating to living beings, as physiology, botany, zoölogy, etc.

An examination of the schemes of study in actual use in public schools will show greater differences that can possibly be warranted by variety of circumstances, if we leave out of consideration differences of opinion as to the relative value of different kinds of knowledge.

The Bureau of Education has kindly furnished us advance sheets from its forthcoming report, containing the results of the first inquiry of its kind yet undertaken in this country, for the purpose of finding the relative number of students taking particular courses of study in 347 public high schools, attended by 64,584 pupils, and the time assigned to leading branches in seventy-one of these schools.

The first table shows that the percentage of students pursuing different branches of study ranges in the following order.

Mathematics, 85.81.
English Language and Literature, 61.78.
Latin, 35.79.
Physics, 25.19.
German, 14.82.
Chemistry, 12.88.
French, 7.71.
Greek, 3.55.

The preponderance of German over chemistry is due to the large number of students of that language in the north central division of the United States, where so many Germans live.

The reports received from these schools as to the time assigned

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to different branches of study differed greatly in character. On account of different interpretations put upon the inquiry and the different conditions existing where the interpretations were the same, it was impossible to embody all the information elicited in a single tabular scheme.

Choice was made of answers relating to courses of four or five years' duration, which are the periods generally comprised in secondary instruction.

In selecting the answers for tabulation, it was necessary also to distinguish between those that pertained to the work of a class as arranged for a continuous course and those that evidently gave the time devoted by all classes to the several studies or the time occupied by the teachers of those studies. The distinction was indicated by the total number of hours making up the school week. The choice was further limited to the reports which included the three lines of study embraced in the inquiry, viz., language, mathematics and physical science.

The reports of seventy-one schools accorded with the basis of choice. They show the following results: S. for scientific, C. for classical.

In the table the first two columns show the number of schools that do not give any instruction in the branches named in the courses as they report them.

The last two columns show the average percentage of time allotted the branches named in those schools in which the given study is a part of the course.

	C.	S.	C.	S.
Latin, . .	7	32	20.75	14.93
Mathematics,	4	8	20.54	22.85
English literature,	12	10	17.32	20.52
Greek, .	36	61	12.70	6.09
German, . .	34	37	8.87	10.71
French, .	39	44	6.66	9.01
Physics, . .	13	8	5.05	6.07
Other sciences,	—	—	4.77	5.01
Chemistry, .	18	15	3.34	4.81

Of the 71 schools, 8 report no classical course, 24 no scientific. Bennington, Vt., reports Latin 50 per cent, other languages 15 per cent, mathematics 14 per cent, physics 1.23 per cent and chemistry 2.07 per cent in what is called a scientific course.

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The average time given to chemistry scarcely differs in the classical and scientific courses, on the whole only 1.47 per cent. Chemistry and physics, taken together, about equal the French or the German. In those courses in which Latin is taught, it receives about one-fifth to one-seventh of the entire time, and it is taught in the scientific courses of 38 of the 71 schools, according to the reports.

If it is taken for granted that by "other studies" is meant chiefly biological sciences, as botany, etc., we shall find appropriated, for the concrete studies, about 13 per cent of the school time in the classical and 16 per cent in the scientific.

It is not asserted that these figures are absolutely correct, but they are the best attainable, and very much better than any mere guesses to show the actual condition of public high-school instruction at the present time in this country.

It is evident from the above facts that there is a diversity of arrangement of courses of study in our high schools beyond that required by any sound judgment, that some of the courses called scientific are misnamed, and that chemistry receives the least attention of any class of studies.

We think that this neglect of chemistry, in our public-school instruction, is one of the causes of many popular mistakes and misapprehensions from which the community suffers.

In addition to the statistics given above for the public high schools, we present herewith similar tables for sixty-six private secondary schools, an analysis of which would show results similar to those already given, with a higher per cent of chemistry.

PRIVATE SCHOOLS.

Classical.		*Scientific.*	
Latin,	24.77	Mathematics,	24.85
Mathematics,	22.46	English Literature,	18.10
English Literature,	14.92	Latin,	16.31
Greek,	9.62	German,	10.44
German,	9.26	Other sciences,	8.33
Physics,	5.56	Physics,	7.05
French,	5.40	French,	6.13
Chemistry,	4.13	Chemistry,	5.68
Other sciences,	4.01	Greek,	3.09

The importance of giving due place to science in secondary pro-

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grams appears the greater when it is remembered that the larger proportion of their students do not pass on to college or technical school. This fact is made very clear by the analysis of the results of a recent inquiry by the Bureau of Education as to the number of secondary students preparing for colleges or superior schools of science.

The proportion of such students in the several classes of schools was as follows: high schools, 15 per cent; private schools for girls, 10 per cent; private schools for boys, 63 per cent; private schools for both sexes, 10 per cent.

But a part of the public-school scholars reach the high school, so that, if some instruction is not given in the grammar school, many children will remain entirely ignorant of chemistry, and our opinion is that it should not only be taught in the high school, but that it should form a part of the instruction given in the higher grades of the grammar school.

In this recommendation we agree with the American Society of Naturalists in their report on science in the schools of last year.

Various methods of teaching may be practised with success, and as the Committee were unable to agree upon specific recommendations, it was judged proper to add their individual suggestions in the hope they may be found useful to those interested.

Signed by

WM. H. SEAMAN,
H. W. WILEY,
W. O. ATWATER,
W. L. DUDLEY.

One method for the grammar school is to employ a skilled lecturer with portable apparatus, who shall deliver one lecture a week to the grammar schools in turn, well illustrated, that the students may have the opportunity of seeing the usual chemical experiments, and that to these lectures be added two recitations per week to the usual teacher. Grammar-school instruction to be confined to descriptive chemistry.

The course in the high school to be not less than two years, the first part to consist of lectures on the principles of chemistry, with pertinent illustrations as far as possible, and with full amount of blackboard exercises on writing formulæ and equations and some stoichiometrical work.

Where the opportunity can be afforded, the last part of the course should, of course, consist of laboratory exercises.

I think the elective system should not be introduced into the high schools further than to have a classical and a scientific course.

WM. H. SEAMAN.

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I believe that science should be taught children from the beginning of their school work. In the primary schools the teaching should be general and not confined to any particular science. The main object being to train the observing, reasoning and descriptive powers of the mind, all the instruction should be given with the objects (or in some cases with good drawings) before the pupil. He should be instructed by judicious questioning, being allowed to do his own observing and reasoning as far as possible. He should be required to prepare written descriptions in the presence of the teacher. I think the work should be wholly conducted without a text-book. This kind of instruction should continue to the high school, when the several sciences may be recognized and taught A course of lectures to high school pupils, with experiments by the teacher, may be better than no chemistry at all, but I believe it is very little better. The chemistry taught in the high and preparatory schools should consist of a systematic course of experiments, logically arranged, so as to lead the pupil to do his own reasoning. The pupil should do his own experimenting and should be taught as recommended for the primary schools.

WM. L. DUDLEY.

I do not believe that special instruction in chemistry should be given. It is impracticable to teach chemistry professionally in a great public school. A short course of lectures, with experiments and possibly simple laboratory work illustrating the general principles of the science, is all that can be reasonably expected.

An elective course which would allow a few pupils to take chemistry as a laboratory and special study is not in harmony with the purpose of a public school.

In general, I would say, for public school pupils, especially in the secondary schools, the fundamental principles of inorganic chemistry and organic, illustrated by a few inexpensive experiments, are sufficient. All studies of chemistry of a professional or elective nature should be left for the elective courses of the college, the technical school and the university.

H. W. WILEY.

I do not think it necessary that chemistry should form a part of every high-school course. It is not advisable to begin the study before the last year or last but one of the course, and the study of chemistry should be preceded by the study of physics.

When chemistry is introduced at all in the high school, there should be given at least two terms, and, if possible, a year's work of, say, two or three hours of lectures and recitations from text-book, and four to six hours of laboratory work in a week.

The best method of teaching is probably recitation from a text-book, accompanied by demonstrative experiments performed by the teacher, and by laboratory work on the part of the student, the latter not to follow rigidly any text-book.

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My idea of the best method of laboratory work is to give each student a subject to work upon, and let him study up carefully from larger works and keep him at it until he can give a satisfactory report. In this way the student comes in contact with the teacher as an individual and does not feel that he is being dealt with *en masse*.

Another feature desirable in the most elementary course, as it seems to me, is the introduction of quantitative experiments, measurements of gases and liquids and weighing with reasonably accurate instruments.

W. A. NOYES.

REPORT OF THE COMMITTEE ON SPELLING AND PRONUNCIATION OF CHEMICAL TERMS. [This report will be found at close of Section C papers.]

REPORT OF P. H. DUDLEY, THE HONORARY AGENT OF TRANSPORTATION.

THE Central Traffic Trunk Line and Southern Passenger Association acted in unison in granting a reduced rate and conditions to members attending the Toronto Meeting.

The above Associations are very courteous, and should future meetings have five hundred or more in attendance, I think a rate of one fare for the round trip could be secured.

The Western Passenger Association refused to grant any concession, giving as a reason, that the number of members who would go from their territory would not warrant a reduction. The New England Passenger Association did not grant any concession, owing to the fact that part of their railroads are in the Trunk Line Association.

The Canadian railways granted concessions through the local transportation committee.

There is great confusion in regard to members obtaining certificates for reduced fare. Of course it is intended that the circular of the local committee should give a full explanation; this however can only be very general and many important specific details for some sections of the country are omitted.

A circular should be prepared stating the railroads granting concessions in each Passenger Association, with specific details in

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regard to the certificates necessary to obtain the reduced rate from the meeting. Such a circular should go out from the office of the Permanent Secretary, and also be printed in the Proceedings.

This would in no way interfere with the circular of the local committee, but would be of great service to many members, as many inquiries and letters have been received this year upon the subject.

New York, August 27, 1889.

Mr. W. R. CALLAWAY, District Passenger Agent of the Canadian Pacific Railway Company, and chairman of the local committee of transportation for the Toronto Meeting, upon reading the foregoing made the following statements:

"I entirely agree with Mr. Dudley in this matter. I think an immense amount of labor would be saved by having a map plate prepared, showing the divisions of the various passenger and traffic associations.

I enclose you herewith such a map as used by the Central Traffic Association. I think a map of this size could readily be made to show the divisions of all the Traffic Associations."

Toronto, August 31, 1889.

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SECTION A.

ATHEMATICS AND ASTRONOMY.

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ADDRESS

BY

ROBERT SIMPSON WOODWARD,

VICE PRESIDENT, SECTION A.

THE MATHEMATICAL THEORIES OF THE EARTH.

THE name of this section, which, by your courtesy, it is my duty to address to-day, implies a community of interest amongst astronomers and mathematicians. This community of interest is not difficult to explain. We can of course imagine a considerable body of astronomical facts quite independent of mathematics. We can also imagine a much larger body of mathematical facts quite independent of and isolated from astronomy. But we never think of astronomy in the large sense without recognizing its dependence on mathematics, and we never think of mathematics as a whole without considering its capital applications in astronomy.

Of all the subjects and objects of common interest to us, the earth will easily rank first. The earth furnishes us with a stable foundation for instrumental work and a fixed line of reference, whereby it is possible to make out the orderly arrangement and procession of our solar system and to gain some inkling of other systems which lie within telescopic range. The earth furnishes us with a most attractive store of real problems; its shape, its size, its mass, its precession and nutation, its internal heat, its earthquakes and volcanoes, and its origin and destiny, are to be classed with the leading questions for astronomical and mathematical research. We must of course recognize the claims of our friends the geologists to that indefinable something called the earth's crust, but, considered in its entirety and in its relations to similar bodies of the universe, the

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earth has long been the special province of astronomers and mathematicians. Since the times of Galileo and Kepler and Copernicus it has supplied a perennial stimulus to observation and investigation, and it promises to tax the resources of the ablest observers and analysts for some centuries to come. The mere mention of the names of Newton, Bradley, d'Alembert, Laplace, Fourier, Gauss, and Bessel, calls to mind not only a long list of inventions and discoveries, but the most important parts of mathematical literature. In its dynamical and physical aspects the earth was to them the principal object of research, and the thoroughness and completeness of their contributions toward an explanation of the "system of the world" are still a source of wonder and admiration to all who take the trouble to examine their works.

HARVARD COLLEGE OBSERVATORY
JUL 18 1892

A detailed discussion of the known properties of the earth, and of the hypotheses concerning the unknown properties, is no fit task for a summer afternoon. The intricacies and delicacies of the subject are suitable only for another season and a special audience. But it has seemed that a somewhat popular review of the state of our mathematical knowledge of the earth might not be without interest to those already familiar with the complex details, and might also help to increase that general interest in science, the promotion of which is one of the most important functions of this association.

As we look back through the light of modern analysis, it seems strange that the successors of Newton, who took up the problem of the shape of the earth, should have divided into hostile camps over the question whether our planet is elongated or flattened at the poles. They agreed in the opinion that the earth is a spheroid, but they debated, investigated, and observed for nearly half a century before deciding that the spheroid is oblate rather than oblong. This was a critical question, and its decision marks perhaps the most important epoch in the history of the figure of the earth. The Newtonian view of the oblate form found its ablest supporters in Huygens, Maupertuis and Clairaut, while the erroneous view was maintained with great vigor by the justly distinguished Cassinian school of astronomers. Unfortunately for the Cassinians, defective measures of a meridional arc in France gave color to the false theory and furnished one of the most conspicuous instances of the deterring effect of an incorrect observation. As you well know, the point was definitely settled by Maupertuis' measurement of the Lapland arc. For this achievement his name has become famous in literature

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as well as in science, for his friend Voltaire congratulated him on having "flattened the poles and the Cassinis" and Carlyle has honored him with the title of "Earth-flattener."[1]

Since the settlement of the question of the form, progress towards a knowledge of the size of the earth has been consistent and steady, until now it may be said that there are few objects with which we have to deal whose dimensions are so well known as the dimensions of the earth. But this is a popular statement, and like most such, needs to be explained in order not to be misunderstood. Both the size and shape of the earth are defined by the lengths of its equatorial and polar axes; and, knowing the fact of the oblate spheroidal form, the lengths of the axes may be found within narrow limits from simple measurements conducted on the surface, quite independently of any knowledge of the interior constitution of the earth. It is evident in fact, without recourse to mathematical details, that the length of any arc, as a degree of latitude or longitude, on the earth's surface, must depend on the lengths of those axes. Conversely, it is plain that the measurement of such an arc and the determination of its geographical position, constitute an indirect measurement of the axes. Hence it has happened that scientific as distinguished from practical geodesy has been concerned chiefly with such linear and astronomical measurements, and the zeal with which this work has been pursued is attested by triangulations on every continent. Passing over the earlier determinations as of historical interest only, all of the really trustworthy approximations to the lengths of the axes have been made within the half century just passed. The first to appear of these approximations were the well founded values of Airy,[2] published in 1830. These, however, were almost wholly overshadowed and supplanted eleven years later by the values of Bessel,[3] whose spheroid came to occupy a most conspicuous place in geodesy for more than a quarter of a century. Knowing as we now do that Bessel's values were considerably in error, it seems not a little remarkable that they should have been so long accepted without serious question. One obvious reason is found in the fact that a considerable lapse of time was essential for the accumulation of new data, but two other possible reasons of a

[1] Todhunter, History of the Theories of Attraction and the Figure of the Earth. London, 1873, Vol. I, Art. 195.

[2] Encyclopedia Metropolitana.

[3] Astronomische Nachrichten No. 438, 1841.

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different character are worthy of notice because they are interesting and instructive, whether specially applicable to this particular case or not. It seems not improbable that the close agreement of the values of Airy and Bessel, computed independently and by different methods—the greatest discrepancy being about one hundred and fifty feet,—may have been incautiously interpreted as a confirmation of Bessel's dimensions, and hence led to their too ready adoption. It seems also not improbable that the weight of Bessel's great name may have been too closely associated in the minds of his followers with the weights of his observations and results. The sanction of eminent authority, especially if there is added to it the stamp of an official seal, is sometimes a serious obstacle to real progress. We cannot do less than accord to Bessel the first place amongst the astronomers and geodesists of his day, but this is no adequate justification for the exaggerated estimate long entertained of the precision of the elements of his spheroid.

The next step in the approximation was the important one of Clarke[1] in 1866. His new values showed an increase over Bessel's of about half a mile in the equatorial semi-axis and about three-tenths of a mile in the polar semi-axis. Since 1866, General Clarke has kept pace with the accumulating data and given us so many different elements for our spheroid that it is necessary to affix a date to any of his values we may use. The later values, however, differ but slightly from the earlier ones, so that the spheroid of 1866, which has come to be pretty generally adopted, seems likely to enjoy a justly greater celebrity than that of its immediate predecessor. The probable error of the axes of this spheroid is not much greater than the hundred thousandth part,[2] and it is not likely that new data will change their lengths by more than a few hundred feet.

In the present state of science, therefore, it may be said that the first order of approximation to the form and dimensions of the earth has been successfully attained. The question which follows naturally and immediately is, how much further can the approximation be carried? The answer to this question is not yet written, and the indications are not favorable for its speedy announcement. The first approximation, as we have seen, requires no knowledge

[1]Comparisons of Standards of Length, made at the Ordnance Office, Southampton, England, by Capt. A. R. Clarke, R.E. Published by order of the Secretary of State for war, 1866.

[2]Clarke, Col. A. R., Geodesy. Oxford, 1880, p. 319.

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of the interior density and arrangement of the earth's mass; it proceeds on the simple assumption that the sea surface is closely spheroidal. The second approximation, if it be more than a mere interpolation formula, requires a knowledge of both the density and arrangement of the constituents of the earth's mass, and especially of that part called the crust. "All astronomy," says Laplace, "rests on the stability of the earth's axis of rotation."[1] In a similar sense we may say all geodesy rests on the direction of the plumb-line. The simple hypothesis of a spheroidal form, assumes that the plumb-line is everywhere coincident with the normal to the spheroid, or that the surface of the spheroid coincides with the level of the sea. But this is not quite correct. The plumb-line, is not in general coincident with the normal, and the actual sea level or geoid must be imagined to be an irregular surface lying partly above and partly below the ideal spheroidal surface. The deviations, it is true, are relatively small, but they are in general much greater than the unavoidable errors of observation and they are the exact numerical expression of our ignorance in this branch of geodesy. It is well known, of course, that deflections of the plumb-line can sometimes be accounted for by visible masses, but on the whole it must be admitted that we possess only the vaguest notions of their cause and a most inadequate knowledge of their distribution and extent.

What is true of plumb-line deflections is about equally true of the deviations of the intensity of gravity from what may be called the spheroidal type. Given a closely spheroidal form of the sea-level and it follows from the law of gravitation, as a first approximation, without any knowledge of the distribution of the earth's mass, that the increase of gravity varies as the square of the sine of the latitude in passing from the equator to the poles. This is the remarkable theorem of Stokes,[2] and it enables us to determine the form, or ellipticity of the earth, by means of pendulum observations alone. It must be admitted, however, that the values of the ellipticity recently obtained in this way by the highest author-

[1] "Toute l'Astronomie repose sur l'invariabilité de l'axe de rotation de la Terre à la surface du sphéroïde terrestre et sur l'uniformité de cette rotation." Mécanique Céleste (Paris, 1882) Tome 5, p. 22.

[2] Stokes, G. G., Mathematical and Physical Papers, Cambridge University Press, 1880, Vol. II.

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ities, Clarke[1] and Helmert,[2] are far from satisfactory, whether we regard them in the light of their discrepancy or in the light of the different methods of computing them. In general terms we may say that the difficulty in the way of the use of pendulum observations still hinges on the treatment of local anomalies and on the question of reduction to sea-level. At present, the case is one concerning which the doctors agree neither in their diagnosis nor in their remedies.

Turning attention now from the surface towards the interior, what can be said of the earth's mass as a whole, of its laws of distribution, and of the pressures that exist at great depths? Two facts, namely, the mean density and the surface density, are roughly known; a third fact, namely, the precession constant, or the ratio of the difference of the two principal moments of inertia to the greater of them, is known with something like precision. These facts lie within the domain of observation and require only the law of gravitation for their verification. Certain inferences, also, from these facts and others, have long been and still are held to be hardly less cogent and trustworthy, but before stating them it will be well to recall briefly the progress of opinion concerning this general subject during the past century and a half.

The conception of the earth as having been primitively fluid was the prevailing one among mathematicians before Clairaut published his Théorie de la Figure de la Terre in 1743. By the aid of this conception Clairaut proved the celebrated theorem which bears his name, and probably no idea in the mechanics of the earth has been more suggestive and fruitful. It was the central idea in the elaborate investigations of Laplace and received at his hands a development which his successors have found it about equally difficult to displace or to improve. From the idea of fluidity spring naturally the hydrostatical notions of pressure and level surfaces, or the arrangement of fluid masses in strata of uniform density. Hence follows, also, the notion of continuity of increase in density from the surface toward the center of the earth. All of the principal mechanical properties and effects of the earth's mass, viz., the ellipticity, the surface density, the mean density, the precession con-

[1] Geodesy, Chap. XIV.

[2] Helmert, Dr. F. R., Die Mathematischen und Physikalischen Theorieen der Höheren Geodäsie. Leipzig, 1880, 1884, II Teil.

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stant, and the lunar inequalities, were correlated by Laplace[1] in a single hypothesis, involving only one assumption in addition to that of original fluidity and the law of gravitation. This assumption relates to the compressibility of matter and asserts that the ratio of the increment of pressure to the increment of density is proportional to the density. Many interesting and striking conclusions follow readily from this hypothesis, but the most interesting and important are those relative to density and pressure, especially the latter, whose dominance as a factor in the mechanics of celestial masses seems destined to survive whether the hypothesis stands or falls. The hypothesis requires that while the density increases slowly from something less than 3 at the surface to about 11 at the center of the earth, the pressure within the mass increases rapidly below the surface, reaching a value surpassing the crushing strength of steel at the depth of a few miles and amounting at the center to no less than three million atmospheres. The inferences, then, as distinguished from facts, are that the mass of the earth is very nearly symmetrically disposed about its center of gravity, that pressure and density except near the surface are mutually dependent, and that the earth in reaching this stage has passed through the fluid or quasi-fluid state.

Later writers have suggested other hypotheses for a continuous distribution of the earth's mass, but none of them can be said to rival the hypothesis of Laplace. Their defects lie either in not postulating a direct connection between density and pressure or in postulating a connection which implies extreme or impossible values for these and other mechanical properties of the mass.

It is clear from the positiveness of his language in frequent allusions to this conception of the earth, that Laplace was deeply impressed with its essential correctness. "Observations," he says, "prove incontestably that the densities of the strata (couches) of the terrestrial spheroid increase from the surface to the center,"[2] and "the regularity with which the observed variation in length of a seconds pendulum follows the law of the squares of the sines of the latitudes, proves that the strata are arranged symmetrically

[1] Mécanique Céleste, Tome 5, Livre XI.

[2] "Enfin il (Newton) regarde la Terre comme homogène, ce qui est contraire aux observations, qui prouvent incontestablement que les densités des couches du sphéroïde terrestre croissent de la surface au centre." Mécanique Céleste, Tome 5, p. 9.

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about the center of gravity of the earth."[1] The more recent investigations of Stokes, to which allusion has already been made, forbid our entertaining anything like so confident an opinion of the earth's primitive fluidity or of a symmetrical and continuous arrangement of its strata. But, though it must be said that the sufficiency of Laplace's arguments has been seriously impugned, we can hardly think the probability of the correctness of his conclusions has been proportionately diminished.

Suppose, however, that we reject the idea of original fluidity. Would not a rotating mass of the size of the earth assume finally the same aspects and properties presented by our planet? Would not pressure and centrifugal force suffice to bring about a central condensation and a symmetrical arrangement of strata similar at least to that required by the Laplacian hypothesis? Categorical answers to these questions cannot be given at present. But whatever may have been the antecedent condition of the earth's mass, the conclusion seems unavoidable that at no great depth the pressure is sufficient to break down the structural characteristics of all known substances, and hence to produce viscous flow whenever and wherever the stress difference exceeds a certain limit, which cannot be large in comparison with the pressure. Purely observational evidence, also, of a highly affirmative kind in support of this conclusion, is afforded by the remarkable results of Tresca's experiments on the flow of solids and by the abundant proofs in geology of the plastic movements and viscous flow of rocks. With such views and facts in mind the fluid stage, considered indispensable by Laplace, does not appear necessary to the evolution of a planet, even if it reach the extreme refinement of a close fulfilment of some such mathematical law as that of his hypothesis. If, as is here assumed, pressure be the dominant factor in such large masses, the attainment of a stable distribution would be simply a question of time. The fluid mass might take on its normal form in a few days or a few months, whereas the viscous mass might require a few thousand or a few million years.

Some physicists and mathematicians, on the other hand, reject

[1] "La régularité avec laquelle la variation observée des longueurs du pendule à secondes suit la loi du carré du sinus de la latitude prouve que ces couches sont disposées régulièrement autour du centre de gravité de la Terre et que leur forme est à peu près elliptique et de révolution." Ibid, p. 17.

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both the idea of existence of great pressures within the earth's mass, and the notion of an approach to continuity in the distribution of density. As representing this side of the question the views of the late M. Roche, who wrote much on the constitution of the earth, are worthy of consideration. He tells us that the very magnitude of the central pressure computed on the hypothesis of fluidity is itself a peremptory objection to that hypothesis.[1] According to his conception, the strata of the earth from the center outwards are substantially self supporting and unyielding. It does not appear, however, that he had submitted this conception to the test of numbers, for a simple calculation will show that no materials of which we have any knowledge would sustain the stress in such shells or domes. If the crust of the earth were self supporting, its crushing strength would have to be about thirty times that of the best cast steel or five hundred to one thousand times that of granite. The views of Roche on the distribution of the terrestrial densities appear equally extreme.[2] He prefers to consider the mass as made up of two distinct parts, an outer shell or crust whose thickness is about one-sixth of the earth's radius, and a solid nucleus having little or no central condensation. The nucleus is conceived to be purely metallic and to have about the same density as iron. To account for geological phenomena, he postulates a zone of fusion separating the crust from the nucleus. The whole hypothesis is consistently worked out in conformity with the requirements of the ellipticity, the superficial density, the mean density, and precession; so that to one who can divest his mind of the notion that pressure and continuity are important factors in the mechanics of such masses, the picture which Roche draws of the constitution of our planet will present nothing incongruous.

In a field so little explored and so inaccessible, though hedged about as we have seen by certain sharply limiting conditions, there is room for a wide range of opinion and for great freedom in the play of hypothesis; and although the preponderance of evidence appears to be in favor of a terrestrial mass in which the reign of pressure is well nigh absolute, we should not be surprised a few decades or centuries hence to find many of our notions on this subject radically defective.

[1] Mémoire sur L'État Intérieur du Globe Terrestre, par M. Édouard Roche; Mémoires de la section des Sciences de l'Académie des Sciences et Lettres de Montpellier, 1880-1884, Tome X.

[2] Ibid.

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If the problem of the constitution and distribution of the earth's mass is yet an obscure and difficult one after two centuries of observation and investigation, can we report any greater degree of success in the treatment of that still older problem of the earth's internal heat, of its origin and effects? Concerning phenomena always so impressive and often so terribly destructive as those intimately connected with the terrestrial store of heat, it is natural that there should be a considerable variety of opinion. The consensus of such opinion, however, has long been in favor of the hypothesis that heat is the active cause of many and a potent factor in most of the grander phenomena which geologists assign to the earth's crust; and the prevailing interpretation of these phenomena is based on the assumption that our planet is a cooling sphere whose outer shell or crust is constantly cracked and crumpled in adjusting itself to the shrinking nucleus.

The conception that the earth was originally an intensely heated and molten mass appears to have first taken something like definite form in the minds of Leibnitz and Descartes.[1] But neither of these philosophers was armed with the necessary mathematical equipment to subject this conception to the test of numerical calculation. Indeed it was not fashionable in their day, any more than it is with some philosophers in ours, to undertake the drudgery of applying the machinery of analysis to the details of an hypothesis. Nearly a century elapsed before an order of intellects capable of dealing with this class of questions appeared. It was reserved for Joseph Fourier to lay the foundation and build a great part of the superstructure of our modern theory of heat diffusion, his avowed desire being to solve the great problem of terrestrial heat. "The question of terrestrial temperatures," he says, "has always appeared to us one of the grandest objects of cosmological studies, and we have had it principally in view in establishing the mathematical theory of heat."[2] This ambition, however, was only partly realized. Probably Fourier underestimated the difficulties of his problem, for his most ingenious and industrious successors in the

[1] Protogée, ou De La Formation et des Révolutions du Globe, par Leibnitz, Ouvrage traduite . . . . . avec une introduction et des notes par Le Dr. Bertrand de Saint Germain, Paris, 1859.

[2] "La question des températures terrestres nous a toujours paru un des plus grands objects des études cosmologiques, et nous l'avions principalement en vue en établissant la théorie mathématique de la chaleur." Annales de Chimie et de Physique, 1824, Tome 27, p. 159.

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same field have made little progress beyond the limits he attained. But the work he left is a perennial index to his genius. Though quite inadequately appreciated by his contemporaries, the Analytical Theory of Heat which appeared in 1820 is now conceded to be one of the epoch-making books. Indeed, to one who has caught the spirit of the extraordinary analysis which Fourier developed and illustrated by numerous applications in this treatise, it is evident that he opened a field whose resources are still far from being exhausted. A little later Poisson took up the same class of questions and published another great work on the mathematical theory of heat.[1] Poisson narrowly missed being the foremost mathematician of his day. In originality, in wealth of mathematical resources, and in breadth of grasp of physical principles he was the peer of the ablest of his contemporaries. In lucidity of exposition it would be enough to say that he was a Frenchman, but he seems to have excelled in this peculiarly national trait. His contributions to the theory of heat have been somewhat overshadowed in recent times by the earlier and perhaps more brilliant researches of Fourier, but no student can afford to take up that enticing though difficult theory without the aid of Poisson as well as Fourier.

It is natural, therefore, that we should enquire what opinions these great masters in the mathematics of heat diffusion held concerning the earth's store of heat. I say opinions, for, unhappily, this whole subject is still so largely a matter of opinion that, in discussing it, one may not inappropriately adopt the famous caution of Marcus Aurelius— "Remember that all is opinion." It does not appear that Fourier reached any definite conclusion on this question, though he seems to have favored the view that the earth in cooling from an earlier state of incandescence reached finally through convection, a condition in which there was a uniform distribution of heat throughout its mass. This is the *consistentior status* of Leibnitz, and it begins with the formation of the earth's crust if not with the consolidation of the entire mass. It thus affords an initial distribution of heat and an epoch from which analysis may start, and the problem for the mathematician is to assign the subsequent distribution of heat and the resulting mechanical effects. But no great amount of reflection is necessary to convince one that the analysis cannot proceed without making a few more

[1]Théorie Mathématique de la Chaleur, Paris, 1835.

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assumptions. The assumptions which involve the least difficulty, and which for this reason, partly, have met with most favor, are that the conductivity and thermal capacity of the entire mass remain constant, and that the heat conducted to the surface of the earth passes off by the combined process of radiation, convection, and conduction, without producing any sensible effect on surrounding space. These or similar assumptions must be made before the application of theory can begin. In addition, two data are essential to numerical calculations, namely, the diffusivity, or ratio of the conductivity of the mass to its thermal capacity, and the initial uniform temperature. The first of these can be observed, approximately, at least; the second can only be estimated at present. With respect to these important points which must be considered after the adoption of the *consistentior status*, the writings of Fourier afford little light. He was content, perhaps, to invent and develop the exquisite analysis requisite to the treatment of such problems.

Poisson wrote much on the whole subject of terrestrial temperatures and carefully considered most of the troublesome details which lay between his theory and its application. While he admitted the nebular hypothesis and an initial fluid state of the earth, he rejected the notion that the observed increase of underground temperature is due to a primitive store of heat. If the earth was originally fluid by reason of its heat, a supposition which Poisson regarded quite gratuitous, he conceived that it must cool and consolidate from the center outwards;[1] so that according to this view the crust of our planet arrived at a condition of stability only after the supply of heat had been exhausted. But Poisson was not at a loss to account for the observed temperature gradient in the earth's crust. Always fertile in hypotheses, he advanced the idea that there exist by reason of interstellar radiations, great variations in the temperature of space, some vast regions being comparatively cool and others intensely hot, and that the present store of terrestrial heat was acquired by a journey of the solar system through one of the hotter regions. "Such is," he says, "in my opinion, the true cause of the augmentation of temperature which occurs as we descend below the surface of the globe."[2] This hypothesis was the

[1] Théorie Mathématique de la Chaleur, Supplement de, Paris, 1837.

[2] "Telle est, dans mon opinion, la cause véritable de l'augmentation de température qui a lieu sur chaque verticale à mesure que l'on s'abaisse au-dessous de la surface du globe." Théorie Mathématique de la Chaleur, Supplement de, p. 15.

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result of Poisson's mature reflection and as such is well worthy of attention. The notion that there exist hot foci in space was advanced also in another form in 1852 by Rankine, in his interesting speculation on the reconcentration of energy. But whatever we may think of the hypothesis as a whole it does not appear to be adequate to the case of the earth unless we suppose the epoch of transit through the hot region exceedingly remote and the temperature of that region exceedingly high. The continuity of geological and paleontological phenomena is much better satisfied by the Leibnitzian view of an earth long subject to comparatively constant surface conditions but still active with the energy of its primitive heat.

Notwithstanding the indefatigable and admirable labors of Fourier and Poisson in this field, it must be admitted that they accomplished little more than the preparation of the machinery with which their successors have sought and are still seeking to reap the harvest. The difficulties which lay in their way were not mathematical but physical. Had they been able to make out the true conditions of the earth's store of heat, they would undoubtedly have reached a high grade of perfection in the treatment of the problem. The theory as they left it was much in advance of observation, and the labors of their successors have therefore necessarily been directed largely towards the determination of the thermal properties of the earth's crust and mass.

Of those who in the present generation have contributed to our knowledge and stimulated the investigation of this subject, it is hardly necessary to say that we owe most to Sir William Thomson. He has made the question of terrestrial temperatures highly attractive and instructive to astronomers and mathematicians, and not less warmly interesting to geologists and paleontologists. Whether we are prepared to accept his conclusions or not, we must all acknowledge our indebtedness to the contributions of his master hand in this field as well as in most other fields of terrestrial physics. The contribution of special interest to us in this connection is his remarkable memoir on the secular cooling of the earth.[1] In this memoir he adopts the simple hypothesis of a solid sphere whose thermal properties remain invariable while it cools by con-

[1] Transactions of the Royal Society of Edinburgh, 1862. Thomson and Tait's Natural Philosophy, Vol. 1, Part II, Appendix D.

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duction from an initial state of uniform temperature, and draws therefrom certain striking limitations on geologic time. Many geologists were startled by these limitations and geologic thought and opinion have since been widely influenced by them. It will be of interest therefore to state a little more fully and clearly the grounds from which his arguments proceed. Conceive a sphere having a uniform temperature initially, to cool in a medium which instantly dissipates all heat brought by conduction to its surface, thus keeping the surface at a constant temperature. Suppose we have given the initial excess of the sphere's temperature over that of the medium. Suppose also that the capacity of the mass of the sphere for the diffusion of heat is known, and known to remain invariable during the process of cooling. This capacity is called diffusivity and is a constant which can be observed. Then from these data, the distribution of temperature at any future time can be assigned, and hence also the rate of temperature increase, or the temperature gradient, from the surface towards the center of the sphere can be computed. It is tolerably certain that the heat conducted from the interior to the surface of the earth does not set up any reaction which in any sensible degree retards the process of cooling. It escapes so freely that, for practical purposes, we may say it is instantly dissipated. Hence if we can assume that the earth had a specified uniform temperature at the initial epoch, and can assume its diffusivity to remain constant, the whole history of cooling is known so soon as we determine the diffusivity and the temperature gradient at any point. Now Sir William Thomson determined a value for the diffusivity from measurements of the seasonal variations of underground temperatures, and numerous observations of the increase of temperature with depth below the earth's surface gave an average value for the temperature gradient. From these elements and from an assumed initial temperature of 7000° Fahr., he infers that geologic time is limited to something between twenty million and four hundred million years. He says: "We must allow very wide limits in such an estimate as I have attempted to make; but I think we may with much probability say that the consolidation cannot have taken place less than 20,000,000 years ago, or we should have more underground heat than we actually have, nor more than 400,000,000 years ago, or we should not have so much as the least observed underground increment of temperature. That is to say, I conclude that Leibnitz's epoch of emergence of

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the *consistentior status* was probably between those dates." These conclusions were announced twenty-seven years ago and were republished without modification in 1883. Recently, also, Professor Tait, reasoning from the same basis, has insisted with equal confidence on cutting down the upper limit of geologic time to some such figures as ten million or fifteen million years.[1] As mathematicians and astronomers we must all confess to a deep interest in these conclusions and the hypothesis from which they flow. They are very important if true. But what are the probabilities? Having been at some pains to look into this matter, I feel bound to state that, although the hypothesis appears to be the best which can be formulated at present, the odds are against its correctness. Its weak links are the unverified assumptions of an initial uniform temperature and a constant diffusivity. Very likely these are approximations, but of what order we cannot decide. Futhermore, if we accept the hypothesis, the odds appear to be against the present attainment of trustworthy numerical results, since the data for calculation, obtained mostly from observations on continental areas, are far too meagre to give satisfactory average values for the entire mass of the earth. In short, this phase of the case seems to stand about where it did twenty years ago, when Huxley warned us that the perfection of our mathematical mill is no guaranty of the quality of the grist, adding that, "as the grandest mill will not extract wheat-flour from peas-cods, so pages of formulæ will not get a definite result out of loose data."[2]

When we pass from the restricted domain of quantitative results concerning geologic time to the freer domain of qualitative results of a general character, the contractional theory of the earth may be said still to lead all others, though it seems destined to require more or less modification if not to be relegated to a place of secondary importance. Old, however, as is the notion that the great surface irregularities of the earth are but the outward evidence of a crumpling crust, it is only recently that this notion has been subjected to mathematical analysis on anything like a rational basis. About three years ago, Mr. T. Mellard Reade[3] announced the doctrine that the earth's crust from the joint effect of its heat and gravitation should behave in a way somewhat analogous to a bent beam,

[1] Recent Advances in Physical Science, London, 1876.
[2] Geological Reform (The Anniversary Address to the Geological Society for 1869).
[3] Reade, T. Mellard, Origin of Mountain Ranges, London, 1886.

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and should possess at a certain depth a "level of no strain" corresponding to the neutral surface in a beam. Above the level of no strain, according to this doctrine, the strata will be subjected to compression and will undergo crumpling, while below that level the tendency of the strata to crack and part is overcome by pressure which produces what Reade calls "compressive extension, thus keeping the nucleus compact and continuous. A little later, the same idea was worked out independently by Mr. Charles Davison,[1] and it has since received elaborate mathematical treatment at the hands of Darwin,[2] Fisher,[3] and others. The doctrine requires for its application a competent theory of cooling and hence cannot be depended on at present to give anything better than a general idea of the mechanics of crumpling and a rough estimate of the magnitudes of the resulting effects. Using Thomson's hypothesis, it appears that the stratum of no strain moves downward from the surface of the earth at a nearly constant rate during the earlier stages of cooling, but more slowly during later stages; its depth is independent of the initial temperature of the earth; and if we adopt Thomson's value of the diffusivity, it will be about two and a third miles below the surface in a hundred million years from the beginning of cooling, and a little more than fourteen miles below the surface in seven hundred million years. The most important inference from this theory is that the geological effects of secular cooling will be confined for a very long time to a comparatively thin crust. Thus, if the earth is a hundred million years old, crumpling should not extend much deeper than two miles. A test to which the theory has been subjected, and one which some[4] consider crucial against it, is the volumetric amount of crumpling shown by the earth at the present time. This is a difficult quantity to estimate, but it appears to be much greater than the theory can account for.

The opponents of the contractional theory of the earth, believing it quantitatively insufficient, have recently revived and elaborated an idea first suggested by Babbage and Herschel[5] in explanation of

[1] On the Distribution of Strain in the Earth's Crust resulting from Secular Cooling; with special reference to the growth of continents and the formation of mountain chains. By Charles Davison, with a Note by G. H. Darwin. Philosophical Transactions, Vol. 178 (1887), A, pp. 231–249.

[2] Ibid.

[3] Fisher, Rev. Osmond, Physics of the Earth's Crust, second edition, London, 1889, Chapter VIII.

[4] Notably Rev. Osmond Fisher. See his Physics of the Earth's Crust, Chapter VIII.

[5] Appendix to the Ninth Bridgewater Treatise (By C. Babbage), second edition, London, 1838.

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the greater folds and movements of the crust. This idea figures the crust as being in a state bordering on hydrostatic equilibrium which cannot be greatly disturbed without a readjustment and consequent movement of the masses involved. According to this view, the transfer of any considerable load from one area to another is followed sooner or later by a depression over the loaded area and a corresponding elevation over the unloaded one; and in a general way it is inferred that the elevation of continental areas tends to keep pace with erosion. The process by which this balance is maintained has been called isostasy,[1] and the crust is said to be in an isostatic state. The dynamics of the superficial strata with the attendant phenomena of folding and faulting are thus referred to gravitation alone, or to gravitation and whatever opposing force the rigidity of the strata may offer. In a mathematical sense, however, the theory of isostasy is in a less satisfactory state than the theory of contraction. As yet we can see only that isostasy is an efficient cause if once set in action; but how it is started and to what extent it is adequate remain to be determined. Moreover, isostasy does not seem to meet the requirements of geological continuity, for it tends rapidly towards stable equilibrium, and the crust ought therefore to reach a state of repose early in geologic time. But there is no evidence that such a state has been attained, and but little if any evidence of diminished activity in crustal movements during recent geologic time. Hence we infer that isostasy is competent only on the supposition that it is kept in action by some other cause tending constantly to disturb the equilibrium which would otherwise result. Such a cause is found in secular contraction, and it is not improbable that these two seemingly divergent theories are really supplementary.

Closely related to the questions of secular contraction and the mechanics of crust movements are those vexed questions of earthquakes, volcanism, the liquidity or solidity of the interior, and the rigidity of the earth's mass as a whole—all questions of the greatest interest, but still lingering on the battle-fields of scientific opinion. Many of the "thrice slain" combatants in these contests would fain risk being slain again; and whether our foundation be liquid or solid, or to speak more precisely, whether the earth may not be at once highly plastic under the action of long continued

[1]Dutton, Capt. C. E. On some of the Greater Problems of Physical Geology, Bulletin Philosophical Society of Washington, Vol. XI, pp. 51-64.

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forces and highly rigid under the action of periodic forces of short period, it is pretty certain that some years must elapse before the arguments will be convincing to all concerned. The difficulties appear to be due principally to our profound ignorance of the properties of matter subject to the joint action of great pressure and great heat. The conditions which exist a few miles beneath the surface of the earth are quite beyond the reach of laboratory tests as hitherto developed, but it is not clear how our knowledge is to be improved without resort to experiments of a scale in some degree comparable with the facts to be explained. In the meantime, therefore, we may expect to go on theorizing, adding to the long list of dead theories which mark the progress of scientific thought, with the hope of attaining the truth not so much by direct discovery as by the laborious process of eliminating error.

When we take a more comprehensive view of the problems presented by the earth, and look for light on their solution in theories of cosmogony, the difficulties which beset us are no less numerous and formidable than those encountered along special lines of attack. Much progress has recently been made, however, in the elaboration of such theories. Roche,[1] Darwin,[2] and others have done much to remove the nebulosity of Laplace's nebular hypothesis. Poincaré[3] and Darwin[4] have gone far towards bridging the gaps which have long rendered the theory of rotating fluid masses incomplete. Poincaré has, in fact, shown us how a homogeneous rotating mass might, through loss of heat and consequent contraction, pass from the spheroidal form to the Jacobian ellipsoidal form, and thence, by reason of its increasing speed of rotation, separate into two unequal masses. Darwin, starting with a swarm of meteorites and gravitation as a basis, has reached many interesting and instructive results in the endeavor to trace out the laws of evolution of a planetary system.[5] But notwithstanding the splendid researches of

[1]Essai sur la Constitution et L'Origine du Système Solaire, par M. Édouard Roche. Mémoires de L'Académie des Sciences et Lettres de Montpellier. Tome VIII, 1873.

[2]On the Precession of a Viscous Spheroid and on the remote History of the Earth, Phil. Trans., Part II, 1879. On the secular changes in the Elements of the Orbit of a Satellite revolving about a tidally distorted Planet, Phil. Trans., Part II, 1880. On the Tidal Friction of a Planet attended by several Satellites, and on the Evolution of the Solar System, Phil. Trans., Part II, 1881.

[3]Sur L'Équilibre d'une Masse Fluide animée d'un mouvement de rotation, Acta Mathematica, Vol. 7, 1885.

[4]On Figures of Equilibrium of Rotating Masses of Fluid, Phil. Trans., Vol. 178, 1887.

[5]On the Mechanical Conditions of a Swarm of Meteorites and on Theories of Cosmogony, Phil. Trans., Vol. 180, 1889.

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these and other investigators in this field, it must be said that the real case of the solar system, or of the earth and the moon, still defies analysis; and that the mechanics of the segregation of a planet from the sun, or of a satellite from a planet, if such an event has ever happened, or the mechanics of the evolution of a solar system from a swarm of meteorites, are still far from being clearly made out.

Time does not permit me to make anything but the briefest allusion to the comparatively new science of mathematical meteorology with its already considerable list of well defined theories pressing for acceptance or rejection. Nor need I say more with reference to those older mathematical questions of the tides and terrestrial magnetism than that they are still unsettled. These and many other questions, old and new, might serve equally well to illustrate the principal fact this address has been designed to emphasize, namely, that the mathematical theories of the earth already advanced and elaborated are by no means complete, and that no mathematical Alexander need yet pine for other worlds to conquer.

Speculations concerning the course and progress of science are usually untrustworthy if not altogether fallacious. But, being delegated for the hour to speak to and for mathematicians and astronomers, it may be permissible to offer, in closing, a single suggestion, which will perhaps help us to orient ourselves aright in our various fields of research. If the curve of scientific progress in any domain of thought could be drawn, there is every reason to believe that it would exhibit considerable irregularities. There would be marked maxima and minima in its general tendency towards the limit of perfect knowledge; and it seems not improbable that the curve would show throughout some portions of its length a more or less definitely periodic succession of maxima and minima. Races and communities as well as individuals, the armies in pursuit of truth as well as those in pursuit of plunder, have their periods of culminating activity and their periods of placid repose. It is a curious fact that the history of the mathematical theories of the earth presents some such periodicity. We have the marked maximum of the epoch of Newton near the end of the seventeenth century, with the equally marked maximum of the epoch of Laplace near the end of the eighteenth century; and, judging from the recent revival of geodesy and astronomy in Europe, and from the well nigh general activity in mathematical and geological research, we may hope if not expect that

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the end of the present century will signalize a similar epoch of productive activity. The minima periods which followed the epochs of Newton and Laplace are less definitely marked but not less noteworthy and instructive. They were not periods of placid repose; to find such one must go back into the night of the middle ages; but they were periods of greatly diminished energy, periods during which those who kept alive the spirit of investigation were almost as conspicuous for their isolation as for their distinguished abilities. Many causes, of course, contributed to produce these minima periods, and it would be an interesting study in philosophic history to trace out the tendency and effect of each cause. It is desired here, however, to call attention to only one cause which contributed to the somewhat general apathy of the periods mentioned, and which always threatens to dampen the ardor of research immediately after the attainment of any marked success or advance. I refer to the impression of contentment with and acquiescence in the results of science, which seems to find easy access to trained as well as untrained minds before an investigation is half completed or even fairly begun. That some such tacit persuasion of the completeness of the knowledge of the earth has at times pervaded scientific thought, there can be no doubt. This was notably the case during the period which followed the remarkable epoch of Laplace. The profound impression of the sufficiency of the brilliant discoveries and advances of that epoch is aptly described by Carlyle in the half humorous, half sarcastic language of Sartor Resartus. "Our Theory of Gravitation," he says, "is as good as perfect: Lagrange, it is well known, has proved that the Planetary System, on this scheme, will endure forever; Laplace, still more cunningly, even guesses that it could not have been made on any other scheme. Whereby, at least, our nautical Logbooks can be better kept; and water transport of all kinds has grown more commodious. Of Geology and Geognosy we know enough; what with the labors of our Werners and Huttons, what with the ardent genius of their disciples, it has come about that now, to many a Royal Society, the creation of a World is little more mysterious than the cooking of a dumpling; concerning which last, indeed, there have been minds to whom the question *How the apples were got in*, presented difficulties." This was written nearly sixty years ago, about the time the sage of Ecclefechan abandoned his mathematics and astronomy for literature to become the seer of Chelsea; but the force of its irony is still applicable, for

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we have yet to learn, essentially, "*How the apples were got in*" and what kind they are.

As to the future we can only guess, less or more vaguely, from our experience in the past and from our knowledge of present needs. Though the dawn of that future is certainly not heralded by rosy tints of over-confidence amongst those acquainted with the difficulties to be overcome, the prospect on the whole has never been more promising. The converging lights of many lines of investigation are now brought to bear on the problems presented by our planet. There is ample reason to suppose that our day will witness a fair average of those happy accidents in science which lead to the discovery of new principles and new methods. We have much to expect from the elaborate machinery and perfected methods of the older and more exact sciences of measuring and weighing—astronomy, geodesy, physics and chemistry. We have more to expect, perhaps, from geology and meteorology with their vast accumulations of facts not yet fully correlated. Much, also, may be anticipated from that new astronomy which looks for the secrets of the earth's origin and history in nebulous masses or in swarms of meteorites. We have the encouraging stimulus of a very general and rapidly growing popular concern in the objects of our enquiries, and the freest avenues for the dissemination of new information; so that we may easily gain the advantage of a concentration of energy without centralization of personal interests. To those, therefore, who can bring the prerequisites of endless patience and unflagging industry, who can bear alike the remorseless discipline of repeated failure and the prosperity of partial success, the field is as wide and as inviting as it ever was to a Newton or a Laplace.

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PAPERS READ.

THE RELATION BETWEEN STELLAR MAGNITUDES, DISTANCES AND MOTIONS.

By Prof. J. R. EASTMAN, U. S. Naval Observatory, Washington, D. C.

[ABSTRACT.]

IN all investigations of the direction and velocity of the motion of the solar system, certain assumptions have always been made in regard to the relative distances of the stars from the sun, and the basis of most of these assumptions is the idea that the magnitude of the star is an index to its distance from the solar system. The first well considered scheme for expressing the relations between stellar magnitudes and distances was devised by F. G. W. Struve in 1827 and it has been tacitly followed since that time. Struve's relations are expressed in the table below:

MAGNITUDES.	1	2	3	4	5	6	7
DISTANCES.	1	1.71	2.57	3.76	5.44	7.86	11.34

If this table be extended it would give the distance for eighth magnitudes stars about 16.5 and ninth magnitudes about 23 ±.

The modern determinations of stellar parallax and proper motion throw grave doubts upon such relations as have been generally assumed.

In his Inaugural Dissertation at Bonn in 1884 Dr. Johann Bischof discussed the proper motions of 845 stars observed by Argelander, including Argelander's well-known list of 250 proper motion stars. This list contains stars from the fifth to the ninth magnitude.

I have divided Bischof's list into four classes, as follows: In the first class are the stars whose proper motions are greater than 1″.0; the second class contains those whose motions are between 0″.701 and 1″.000; the third class those whose motions are between 0″.401 and 0″.700 and the fourth class those with motions less than 0″.401, and the results are given below:

TABLE I.

	NUMBER OF STARS.	MEAN MAGNITUDE.	MEAN PROPER MOTION.
			″
Class I	19	7.83	1.908
" II	24	7.71	0.825
" III	65	7.42	0.516
" IV	237	7.17	0.246

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To show that the agreement in the magnitudes is not accidental I have divided the number of stars in the third class into two groups *seriatim* and those in the fourth class into six groups as shown below.

TABLE II.

	NUMBER OF STARS.	MEAN MAGNITUDE.	MEAN PROPER MOTION.
			"
Class III, group 1	33	7.38	0.533
" " " 2	32	7.46	0.498
Class IV, group 1	40	7.22	0.260
" " " 2	40	7.29	0.274
" " " 3	40	7.04	0.235
" " " 4	39	7.24	0.249
" " " 5	39	7.20	0.234
" " " 6	39	7.08	0.226

This shows conclusively that the results for mean magnitude and mean proper motion are entirely free from accidental variations.

In order to extend the examination to stars of greater magnitude I have collated the proper motions of the 307 stars larger than the fifth magnitude contained in Newcomb's Catalogue of Standard Clock and Zodiacal Stars, Astronomical Papers of the American Ephemeris, 1882. These were divided into four groups according to the same method used with Argelander's stars and the results are given below.

TABLE III.

	NUMBER OF STARS.	MEAN MAGNITUDE.	MEAN PROPER MOTION.
			"
Class I	8	2.41	2.278
" II	5	3.54	0 841
" III	10	2.76	0.526
" IV	284	3.66	0.099

In order to test the uniformity of the results in Class IV the stars were divided into five nearly equal groups with the result as given below.

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TABLE IV.

	NUMBER OF STARS.	MEAN MAGNITUDE.	MEAN PROPER MOTION.
			″
Class IV, Group 1	57	3.77	0.104
" " " 2	57	3.56	.087
" " " 3	57	3.51	.110
" " " 4	57	3.60	.097
" " " 5	56	3.84	.098

This table shows the same freedom from accidental variations as table II. The four tables also show, that, with the exception of the few stars about the first magnitude, the proper motion does not decrease with the decrease in the magnitude but as in table I the proper motion is *greatest* for the smaller stars. This is still more prominently shown in the following table. I have separated the 652 stars, including those of Bischof's and Newcomb's lists, into groups according to magnitude.

I have tabulated as *first* magnitudes all stars greater than 1.5 mag.; as *second* those between 1.6 mag. and 2.5 mag. inclusive; as *third* those between 2.6 mag. and 3.5 mag.; as *fourth* those between 3.6 mag. and 4 5 mag.; as *fifth* those between 4.6 mag. and 5.5 mag.; as *sixth* those between 5.6 mag. and 6.5 mag.; as *seventh* those between 6.6 mag. and 7.5 mag.; as *eighth*, those between 7.6 mag. and 8.5 mag. and as *ninth* all those fainter than 8.6 mag. inclusive. These are exhibited below.

TABLE V.

NUMBER OF STARS.	MEAN MAGNITUDE OF GROUP.	MEAN PROPER MOTION OF GROUP.
		″
18	1.11	0.524
44	2.15	0.161
67	3.07	0.181
98	4.05	0.141
90	4.87	0.173
64	6.12	0.292
128	7.05	0.421
114	8.08	0.460
29	8.78	0.678

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ON THE SOLAR PARALLAX AND ITS RELATED CONSTANTS. By Prof. WM. HARKNESS, Washington, D. C.

[THIS paper consisted of a brief account of an investigation soon to be published by the U. S. Naval Observatory.]

THE POLAR TRACTRIX. By Prof. J. BURKITT WEBB, Stevens Institute, Hoboken, N. J.

[ABSTRACT.]

IN connection with Amsler's Planimeter,[1] Sir Robert Ball has pointed out that the pointer may be made to trace such a curve as to produce no motion of the registering wheel. Some years ago, in writing a discussion of this planimeter the formula for such a curve was developed and has not been met with elsewhere.

The planimeter consists of an arm OP, pivoted at O to a flat surface, on which is drawn any curve whose area is to be determined. A second arm, PQ, is pivoted to the first, and its opposite end Q is furnished with a pointer, which is passed completely around the curve in the process of measuring its area. The pointer and the axes of the pivots are all parallel to each other and perpendicular to the plane surface. To the arm PQ are attached journals in which a measuring wheel runs, whose axis is parallel to the line PQ. This wheel may occupy any position with regard to the points PQ. It turns freely in its journals and rests with a narrow edge and some friction upon the surface, so that during the motion of the pointer it is revolved one way or the other by the friction, and this revolution is read off by means of suitable graduations on its perimeter, which reading also gives the area.

Let p be the point where the plane of the wheel cuts PQ, and W the point of contact of the wheel with the paper, then the motion of the wheel is independent of the distance Wp and we may suppose a planimeter in which W and p coincide to be the normal form of the instrument, and designate the contact point by Wp. Instead, also, of supposing Q to trace such a curve as will cause no revolution of the wheel, it will be more direct to seek the curve which Wp must follow in that case. This curve is a "polar tractrix" and is the fundamental curve of the family of curves traced by all points (of which Q is one) connected with the arm PQ.

Dispensing then with the point Q, and thus reducing the arm PQ to PWp the problem is to revolve the arm $OP = c$ about O and let it drag the arm $PWp = b$ after it, Wp resting with friction on the flat surface, and to find the curve traced by Wp on the surface.

One form of this curve is evidently a circle of the radius

$$r_0 = \sqrt{c^2 - b^2},$$

which is also the circular asymptote to the general form of the curve.

[1] See demonstration of the action of this planimeter in Williamson's Calculus.

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The consideration which leads to the differential equation of the curve is that Wp must move always in the line through P, or that PWp is always tangent to the curve.

The differential equation of the curve is

$$\rho\, d\gamma + b\, d\beta = 0$$

in which ρ is the perpendicular from O upon the plane of the wheel and γ and β, the respective angles made by the arms OP with a prime radius through O and PWp with OP.

The resulting equation of the curve is, when the prime radius is chosen so as to be an axis of symmetry of the curve, in which case $\gamma = 0$ for $\beta = 0$,

$$\gamma \tan \beta' = \log_e \mp \frac{\sin \frac{\beta + \beta'}{2}}{\sin \frac{\beta - \beta'}{2}}$$

where the minus and plus signs refer to two branches of the tractrix respectively within and without the asymptote or "primitive circle" and where β' is the value of β corresponding to $\rho = 0$.

If c be made equal to ∞, as in "Coffin's Averaging Instrument" the curve becomes the common tractrix.

The form of the curve is that of two right handed and two left handed spirals, which are symmetrically placed with respect to the prime radius and which meet in two cusps at points upon it distant respectively $c - b$ and $c + b$ from O, and which after an infinite number of turns merge into the primitive circle.

The curve may be accurately drawn by a simple construction, mostly geometrical after which the curve traced by any other point (as Q) moving with PQ is readily added.

A PRECESSION MODEL. By Prof. J. BURKITT WEBB, Stevens Institute, Hoboken, N. J.

[ABSTRACT.]

THE essential feature of the model presented for the illustration and imitation of the effect of precession is a sphere supported by jets of air, so as to be essentially free in space to rotate though not to translate. With such a model and jets of high pressure air applied so as to suitably impinge upon the surface, in connection, if preferred, with magnetic attraction, the combination of rotations in space as well as the combination of a rotation with an angular acceleration (which is the phenomenon of precession) may be produced. The sphere has also means by which its three moments of inertia may be varied at will, so as to imitate all possible masses, which provides for the production of various other phenomena.

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THE CENTRIFUGAL CATENARY. By Prof. J. BURKITT WEBB, Stevens Institute, Hoboken, N. J.

[ABSTRACT.]

IN the governors attached to steam and other engines and in various other apparatus, springs are used under the influence of centrifugal force. The variation of the form and tension of such a spring, due to such force, may or may not be sufficiently great to measurably change the action of the spring, but cases will certainly arise in which a knowledge of the action of centrifugal force will be necessary for their satisfactory treatment. I have, therefore, investigated some of the curves assumed by elastic and non-elastic chains in a field of centrifugal force, the former representing spiral springs whose lateral stiffness is neglected.

Such a curve may be called a "Centrifugal Catenary" and will belong to one of the following divisions:

Non-elastic or elastic, which may be further classified according to whether the points A and B, revolving about an axis and to which the chain is attached, are;

(a) in a plane passing through the axis of rotation;

(b) in a plane perpendicular to the axis of rotation;

(c) in neither.

The chain may also be either; In tension, in which case the equilibrium is stable; or in compression, which is a case of unstable equilibrium.

The chain may also be confined in various ways, as, for instance, it may be compelled to remain rectilinear and allowed only to adjust its tension to suit the centrifugal field. This is, substantially, the practical case of a short, stiff spiral spring in the fly-wheel of a steam engine and was the means of suggesting a general discussion of springs and chains in a field of centrifugal force.

It will be noticed that the curve taken by a girl's skipping rope is case (a) with a non-elastic chain.

A PROPOSED CATALOGUE OF DECLINATIONS (By permission of the Superintendent). By HENRY FARQUHAR, Coast Survey Office, Washington, D. C.

[ABSTRACT.]

REASONS for recommending the formation of a catalogue of declinations, to the highest degree of precision now attainable, by the U. S. Coast Survey, including:

(1) The large number of stars whose declination are needed, for latitudes observed by the Talcott method.

(2) Proof that the greater part of the error of latitudes so observed on the Survey, results from weak declinations.

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(3) Indication that a considerable improvement could be made by a more thorough systematic study of the data, given by a comparison of the probable errors of the provisional places used for Coast Survey latitudes with those of the Northern Boundary Catalogue as deduced by Boss.

(4) Necessity of care to avoid systematic error of declinations in the solution of geodetic problems; illustrated by the effect on the comparison of astronomic and geodetic latitudes at the extremities of a long arc (Eastport to Atlanta) connected by the triangulation of the Survey, of the circumstance that the observations at one end were generally later than at the other, so that the star-places contained more of whatever systematic error there was in the declination proper-motions used.

(5) Improbability that, if the Coast Survey declined this work, any other agency could be expected to undertake it.

(6) Use of such a catalogue for ends other than geodetic.

Declination Standards: account of the three different ones promulgated by Dr. Auwers.

Examination of the claims of Auwers' Bradley to be accepted as fundamental, as tested by four sets of data:

(1) Differences of declinations from stars observed above and below pole, with quadrant to north.

(2) Differences of declinations observed near zenith, in both positions of quadrant.

(3) Differences between very low observations below pole and observations in southward position of quadrant.

(4) Differences from Bessel's "Fundamenta" between $+ 14^\circ$ and $- 14^\circ$ declination.

Derivation of a general formula for the correction of all Bradley's declinations, $\mp ''.63 - ''.56 \cos \alpha - ''.02 \sin \alpha + 2''.01 \cos \delta \pm ''.66 \sin \delta$ for northern stars at the two culminations; $- ''.72 + ''.56 \cos \alpha + ''.02 \sin \alpha + 2''.01 \cos \delta + ''.66 \sin \delta$ for southern.

Comparison of these declinations with the Boss standard, before and after this correction.

ON THE USE OF A FLOATING MIRROR AS AN AUXILIARY TO A MERIDIAN CIRCLE. By Prof. GEO. C. COMSTOCK, Madison, Wis.

[ABSTRACT.]

THIS paper contains a description of an apparatus by which the principle of the almucantar is employed in the use of a meridian circle for the determination of horizontal points. It consists essentially of a mirror, with plane parallel faces, supported upon a platform which floats in a basin of mercury. This basin rotates about a vertical axis, and the mirror may be rotated about a horizontal axis. The method of observing is precisely

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similar to that employed in ordinary observations of the nadir. By means of six pointings of the telescope, all errors of the instrument may be eliminated and experiments with the meridian circle of the Washburn Observatory show that the horizontal point may be determined with a probable error not greater than $0''.2$. By measuring the angle between the nadir and the north and south horizons the sine and cosine flexures of the meridian circle may be readily determined with a high degree of precision.

A DESIDERATUM IN THE PRESENTATION OF MATHEMATICAL TRUTH. By Prof. CHARLES H. CHANDLER, Ripon, Wis.

[ABSTRACT.]

IT is a prevalent belief that but few are so constituted as to enjoy mathematical study; and the small membership of the mathematical section of the association seems to harmonize with this view.

But it seems reasonable that a change in the methods of presenting mathematical truth in text-books or papers on original investigations might greatly modify both of these conditions. The interest in the physical and natural sciences has been greatly advanced within a few years, by that change in methods by which readers are taken, as it were, into the laboratory, and led to appreciate the motives for the several steps of the investigations in progress.

So, too, mathematical students should be shown, as they proceed, the motives for successive processes, and thus be able to recognize their advance toward clearer light, without waiting for the result to justify the course pursued.

NEW ARRANGEMENT FOR AN ASTIGMATIC EYE-PIECE. By JNO. A. BRASHEAR, Allegheny, Pa.

[ABSTRACT.]

IT is the purpose of this paper to describe a simple arrangement of attaching an astigmatic lens to any form of eye-piece so as to correct the astigmatism of the eye.

THE JENA OPTICAL GLASS. By JNO. A. BRASHEAR, Allegheny, Pa.

[ABSTRACT.]

IT is the purpose of this paper to give a few notes on the value of the new Jena optical glass. First, on its transparency; second, on its equal

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density and perfect annealing; third, on the high value of the tables furnished with it, and fourth, on the reliability of the constants of its indices and partial dispersion; and, finally, on its permanence.

THE HASTINGS ACHROMATIC OBJECTIVE. By J. H. BRASHEAR, Allegheny, Pa.

[ABSTRACT.]

THE investigation of an objective, made by the writer from Jena glass Nos. 14 and 27, from computations made by Dr. Hastings, shows, first, that the focal length came out within a fraction of a millimetre of the computed focus; second, that spherical aberration was entirely eliminated, requiring no after work; third, that a careful spectroscopic study of its achromatism, shows (1), by Professor Harkness' method, an almost perfectly parallel spectrum, deviating only a very minute quantity in the extreme violet; and (2), by a study of artificial stars made by throwing the various colors of the spectrum upon a silvered convex surface, that the change in focus did not amount to one-fifth of a millimetre for the visible spectrum; and, fourth, that the objective will prove to be as perfect for photographic, as for visual, work.

THE PERUVIAN ARC. By E. D. PRESTON, Assistant U. S. Coast and Geodetic Survey, Washington, D. C.

[ABSTRACT.]

IN order to determine the size and shape of the earth there were measured, one hundred and fifty years ago, two meridional arcs: one in Peru and the other in Lapland.

The Peruvian work is examined in this paper with reference to the degree of accuracy attained and a comparison is made between the uncertainties of these measures and those resulting from work with modern instruments, and following more recent methods.

It is shown that the probable errors are much larger than would be indicated by the agreement of the published results, and that therefore the concordance of this arc with those in other parts of the world is no proof of its accuracy.

By far the most significant errors come from the astronomical observations and the unavoidable uncertainties here, either from the imperfection of the instruments, or the attraction of the high mountains, are shown to perceptibly affect the elements of the earth's figure now in use.

The conclusion is that geodesy to-day demands the remeasurement of this arc.

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AUTOMATIC PHOTOGRAPHIC TRANSITS. By Prof. FRANK H. BIGELOW, Nautical Almanac Office, Washington, D. C.

[ABSTRACT.]

IN the history of observations of precision there are three distinct periods: (1) an English school of which John Pond is a type; (2) a German school represented by Bessel; and (3) a modern school of photography as applied to transits.

For the automatic observation of star transits by photographic record, and consequent elimination of the Personal Equation, an apparatus is described whose method and operation seem satisfactory. It is simple, and can be attached to the telescopes now used, with a little care, thus rendering them available for the old and the new method. Transits of 4° Mag. stars are obtained with a six-inch glass, and the process is so rigorous as to admit the use of the most sensitive plates.

ON THE GRADUATION OF MERIDIAN CIRCLES IN SITU. By Prof. WM. A. ROGERS, Waterville, Me.

[ABSTRACT.]

THIS paper consists of a description of the process by which a circle having a diameter of five feet was graduated to degrees with subdivisions to 2′. After the third trial the greatest error of the 6° points, *including the error of eccentricity*, was found to be within 1″.6 while the average error was only 0″.2

The circle has an axis six inches in diameter.

ON THE PROPER MOTIONS OF THE STARS IN THE HARVARD COLLEGE OBSERVATORY ZONE BETWEEN THE LIMITS OF 50° AND 55° DECLINATION. By Prof. WM. A. ROGERS, Waterville, Me.

ASTRONOMICAL OBSERVATIONS MADE WITH THE GREAT TELESCOPE OF THE LICK OBSERVATORY SINCE JUNE, 1888. By Prof. EDWARD S. HOLDEN, San José, Cal.

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Double star discoveries and measures made at the Lick Observatory, August 1, 1888, to August 1, 1889. By S. W. Burnham, Mount Hamilton, Cal.

The results of the double star observations during the past year are given as briefly as possible in the following pages. A few of the new double stars have appeared in No. 2875 of *Astronomische Nachrichten*. A later list has been sent to the same Journal, but not yet printed. The β numbers of these stars are given (β 1026 to β 1092). So far as possible, every star, new and otherwise, has been measured on at least three nights. The mean of these measures is given, with the number of nights in each case.

The measures have been made in the usual manner, and with micrometers of the ordinary Clark form. In an abstract of this kind, it would not be easy to indicate the instrument used in each case. In many instances, the mean is derived from measures with both the 36-inch and 12-inch refractors; but the largest part of the measures were made with the large telescope, and most of the new stars found with it. In selecting old double stars for measurement, the superior power of the 36-inch for this class of work has been borne in mind, and objects too difficult to be observed with ordinary instruments, and pairs which for many years have been regarded as single, have been chosen.

With reference to the optical performance of the Lick telescope, it is only necessary to refer to the catalogue of new stars. A glance at this list will make it apparent to any observer that not only is this instrument the most powerful telescope in the world, as intended by its donor, but that in definition and all other essential requisites it is practically perfect for double star work, the severest possible test for the performance of any telescope. The micrometer, driving-clock pier and other mechanical details are equally perfect for the same purpose; and there is no excuse for the observer doing other than his best work.

Catalogue of 123 new double stars discovered at the Lick Observatory.

β 1026. Lalande 58.

	R. A. $0^h\ 5^m\ 48^s$		Decl. $+52°\ 57'$		
1888.76	329°.6	0″.48	8.1 . .	8.9	4n

β 1027. D. M. (20°) 15

	R. A. $0^h\ 8^m\ 44^s$		Decl. $+20°\ 50'$		
1888.82	186° 8	1″.54	7.2 . .	10.3	3n

Lalande 655.

	R. A. $0^h\ 23^m\ 35^s$		Decl. $+59°\ 19'$		
1889.53	244°.6	0″.70	5.7 . .	9.5	3n

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28 ANDROMEDÆ.

R. A. 0h 23m 47s Decl. + 29° 5′

1889.51	360°.1	2″.42	5.5 . .	13.5	3n

A. OE. 534.

R. A. 0h 29m 46s Decl. + 57° 51′

A and B.

1889.59	265°.2	0″.19	9.5 . .	9.6	1n

A B and C.

1889.60	61°.8	33″.38	. .	8.9	3n

υ' CASSIOPEÆ.

R. A. 0h 47m 53s Decl. + 58° 19′

1889.60	75°.2	12″.79	6 . .	13.5	3n

β 1028. γ CASSIOPEÆ.

R. A. 0h 48m 50s Decl. + 60° 1′

1888.69	255°.9	2″.18	3 . .	11	6n
1889.58	255°.4	2″.15	. .	11.6	4n

B. A. C. 255.

R. A. 0h 49m 33s Decl. + 59° 43′

1889.57	270°.2	0″.15	6.1 . .	6.8	4n

Very close pair 21′ *s* of γ Cassiopeæ.

LALANDE 2155.

R. A. 1h 7m 5s Decl. + 60° 18′

1889.54	43°.6	0″.48	7.4 . .	7.4	3n

β 1029. ζ PISCIUM.

R. A. 1h 7m 27s Decl. + 6° 56′

B and C.

1888.71	248°.7	0″.93	. .	11	5n

A and B (= Σ 100)

1888.71	63°.5	23″.72	. .		5n

ψ CASSIOPEÆ.

R. A. 1h 17m 27s Decl. + 67° 30′

A and B.

1889.52	41°.2	3″.19	4.5 . .	13.5	4n

C and D (= Σ 117).

1889.52	254°.7	2″.86	9.6 . .	9.8	4n

A and C (= Σ 117).

1889.52	107°.4	28″.01	. .		4n

A. OE. 1510.

R. A. 1h 19m 38s Decl. + 59° 40′

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B and C.

1889.58	336°.3	0″.84	10.3	. .	10.3	3n

A and BC.

1889.58	265°.4	60″.29	8.2	. .		3n

This is 1m 41s *f*, and 3′ n of δ Cassiopeæ.

44 Cassiopeæ.

R. A. 1h 35m 12s Decl. + 59° 56′

1889.54	8°.8	1″.73	6.2	. .	12.5	3n

Groombridge 370.

R. A. 1h 35m 51s Decl. + 52° 17′

1889.60	197°.2	2″.86	7.2	. .	11.8	3n

β 1030. D. M. (21°) 418.

R. A. 3h 3m 11s Decl. + 21° 17′

1888.83	164°.6	0″.58	8.4	. .	8.4	3n

β 1039. Lalande 6084.

R. A. 3h 10m 59s Decl. + 7° 13′

1889.00	209°.4	1″.87	7	. .	13	3n

β 1040. Lalande 6591.

1888.91	337°.0	3″.54	8	. .	11.7	3n

β 1041. W^2 III, 798, 798.

R. A. 3h 37m 9s Decl. + 27° 26′

A and B.

1888.91	39°.9	123″.57	7	. .	7	3n

B and C.

1889.91	347°.8	7″.87		. .	12.8	3n

The wide pair is O Σ (app.) 38.

Pleiades.

R. A. 3h 41m 26s Decl. + 23° 49′

1889.59	59°.3	0″.33	9.2	. .	10	2n

This is D.M. (23°) 554, and is 1m 4s *f*, and 4′.3 *n* of Alcyone.

Pleiades.

R. A. 3h 42m 58s Decl. + 23° 51′

1889.59	51°.7	0″.40	11.5	. .	11.5	1n

Too faint to be found in any Star Catalogue. Place from the Paris map of the Pleiades. It is 55s *f*, and 4′.6 *n* of 28 Tauri.

β 1042. Lalande 2372.

R. A. 3h 52m 36s Decl. — 3° 0′

A and B.

1888.92	93°.8	55″.93	7.5	. .		3n

B and C.

1888.92	35°.1	1″.09	8.7	. .	9.5	4n

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β 1031. α TAURI.

R. A. $4^h\ 29^m\ 2^s$ Decl. $+16°\ 16'$

A and B (= β 550).

1888.82	109°.5	30″.90	1	. .	14	2n

A and C (= Σ 2 App. II).

1888.81	34°.9	116″.91		. .		3n

C and D.

1888.81	281°.1	2″.34	9	. .	12	3n

β 1043. 8 CAMELOPARDI.

R. A. $4^h\ 30^m\ 28^s$ Decl. $+52°\ 50'$

1888.92	297°.3	3″.92	5	. .	12	3n

β 1044. D. M. (16°) 637

R. A. $4^h\ 33^m\ 0^s$ Decl. $+16°\ 16'$

1888.91	218°.5	1″.03	9	. .	11	3n

This follows α Tauri $3^m\ 58^s$, and is $0'.5$ n

β 1045. 99 TAURI.

R. A. $4^h\ 50^m\ 32^s$ Decl. $+23°\ 46'$

1889.09	6°.2	6″.30	6	. .	12.3	3n

β 1046. 9 AURIGÆ.

R. A. $4^h\ 56^m\ 59^s$ Decl. $+51°\ 26'$

A and B.

1888.92	93°.8	6″.29	5.5	. .	12.7	3n

A and C (= h. VI. 35)

1888.92	60°.8	89″.92		. .	9	2n

β 1047. AURIGÆ 47.

R. A. $5^h\ 2^m\ 13^s$ Decl. $+27°\ 53'$

B and C.

1889.09	75°.3	0″.44	8.7	. .	9.2	3n

A and BC (Σ = 645)

1889.09	26°.6	11″.69	7.2	. .		3n

β 1048. LALANDE 10437.

R. A. $5^h\ 26^m\ 37^s$ Decl. $-1°\ 41'$

1889.13	358°.2	2″.20	6.2	. .	10.7	3n

β 1049.

R. A. $5^h\ 27^m\ 3^s$ Decl. $-1°\ 48'$

C and D.

1888.91	296°.1	0″.76	8.7	. .	9.7	4n

A and B (= Σ 734).

1888.91	355°.2	1.61	7	. .	8	4n

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A and C (= Σ 784).

1888.91	242°.8	29″.42				

β 1050. BOND 974.

R. A. 5h 30m 55s Decl. — 5° 33′

1889.03	283°.6	0″.67	10.5	. .	11.7	3n

In the nebula of Orion.

β 1051. BOND 1096.

R. A. 5h 32m 1s Decl. — 4° 57′

1889.09	24°.7	0″.75	10.1	. .	10.7	3n

In the nebula of Orion.

β 1052. σ ORIONIS.

R. A. 5h 32m 43s Decl. — 2° 40′

A and B.

1888.81	357°.0	0″.26	4	. .	6	4n

A B and C (Σ 762).

1888.84	237°.1	11″.23		. .		3n

A B and D (Σ 762).

1888.84	83°.3	12″.84		. .		3n

A B and E (Σ 762).

1888.85	60°.5	41″.18		. .		1n

β 1052. LALANDE 10776.

R. A. 5h 35m 39s Decl. — 2° 57′

1889.14	189°.1	0″.66	7.2	. .	8.2	3n

β 1053. AURIGÆ 146.

R. A. 5h 45m 18s Decl. + 37° 19′

1888.92	283°.2	0″.43	7.5	. .	9.5	

β 1054. 136 TAURI.

R. A. 5h 45m 47s Decl. + 27° 35′

1889.08	232°.2	15″.00	6	. .	12	3n

β 1055. B. A. C. 1899.

R. A. 5h 51m 32s Decl. + 44° 35′

A and B.

1888.92	332°.9	1″.61	6.7	. .	11.5	3n

A and C (= H. VI.91).

1888.92	329°.7	33″.35		. .	9.2	3n

β 1056. μ ORIONIS.

R. A. 5h 55m 47s Decl. + 9° 39′

1889.11	272°.5	16″.80	4	. .	14	3n

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β 1057. AURIGÆ 183.

R. A. 5h 58m 42s Decl. + 29° 32′

1889.10	209°.5	9″.98	6.3	. .	11.2	3n

β 1058. 4 GEMINORUM.

R. A. 6h 3m 13s Decl. + 23° 1′

1889.13	104°.3	0″.41	7.2	. .	7.5	2n

β 1059. μ GEMINORUM.

R. A. 6h 15m 42s Decl. + 22° 34′

B and C.

1889.10	266°.7	0″.80	9.8	. .	10.7	3n

A and B C.

1889.10	141°.0	122″.49		. .	3	3n

β 1060. LALANDE 13491.

R. A. 6h 52m 38s Decl. + 3° 46′

1889.15	58°.3	3″.01	7	. .	12	2n

β 1061. x ARGUS.

R. A. 7h 33m 55s Decl. — 26° 32′

B and C.

1889.12	229°.3	6″.46	13.8	. .		3n

A and B (= H. III. 27).

1889.12	318°.5	9″.98	4.1	. .	4.1	3n

β 1062. 82 GEMINORUM.

R. A. 7h 41m 23s Decl. + 23° 26′

1889.10	32°.3	4″.06	6	. .	12.5	3n

β 1063. ξ ARGUS.

R. A. 7h 44m 15s Decl. — 24° 34′

1889.12	188°.7	4″.63	3.5	. .	14.8	3n

β 1064. 19 ARGUS.

R. A. 8h 5m 39s Decl. — 12° 34′

A and B.

1889.08	244°.9	1″.84	6	. .	12.5	4n

A and C (= H. IV. 26).

1889.08	255°.8	70″.68		. .	9	3n

β 1065. β CANCRI.

R. A. 8h 10m 0s Decl. + 9° 33′

1889.11	294°.7	29″.14	3.5	. .	14	3n

β 1066. LALANDE 16489.

R. A. 8h 18m 31s Decl. + 9° 49′

1889.12	187°.7	2″.25	6.8	. .	13.2	3n

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β 1067. *o* URSÆ MAJORIS.

R. A. 8h 20m 17s Decl. + 61° 7′

1889.22	191.4	7″.01	8½	. .	15.2	3n

β 1068. LALANDE 17381.

R. A. 8h 43m 1s Decl. + 9° 19′

A and B.

1889.19	189°.9	0″.45	7.7	. .	8.8	3n

A B and C.

1889.14	313°.0	17″.80		. .	12.8	2n

β 1070. D. M. (26°) 1940.

R. A. 9h 17m 13s Decl. + 26° 46′

1889.13	71°.8	0″.50	9.1	. .	9.2	3n

Near *x* Leonis, 27s f, and 4′*n*.

β 1071. *θ* URSÆ MAJORIS.

R. A. 9h 25m 50s Decl. + 52° 11′

1889.23	74°.9	5″.09	3	. .	13.7	3n

β 1072.

R. A. 9h 58m 20s Decl. — 17° 31′

A and B.

1889.13	42°.6	10″.90		. .	12.3	3n

A and C (= Sh. 110)

1889.13	273°.2	21″.23	6.9	. .	7.1	3n

β 1073. LALANDE 20428.

R. A. 10h 26m 26s Decl. — 5° 27′

1889.29	46°.9	3″.02	7	. .	11.5	3n

β 1074. LALANDE 20453.

R. A. 10h 28m 20s Decl. + 46° 26′

1889.27	208°.4	2″.10	6.4	. .	11.2	3n

β 1075. φ^3 HYDRÆ.

R. A. 10h 30m 25s Decl. — 15° 43′

1889.14	277°.1	3″.03	6	. .	13	3n

β 1076. 55 LEONIS.

R. A. 10h 49m 32s Decl. + 1° 23′

1889.28	49°.7	0″.99	5.8	. .	10.3	3n

β 1077. *a* URSÆ MAJORIS.

R. A. 10h 56m 19s Decl. + 62° 24′

1889.19	326°.1	0″.91	2	. .	11.1	4n

β 1078. CRATERIS 79.

R. A. 11h 38m 46s Decl. — 13° 48′

1889.30	49°.8	8″.22	6.3	. .	12.2	3n

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β 1079. LALANDE 22586.

R. A. 11h 54m 34s Decl. — 21° 7′

1889.80	147°.9	11″.69	6.2	. .	13.3	3n

β 1080. 17 COMÆ.

R. A. 12h 22m 55s Decl. + 26° 35′

B and C.

1889.11	156°.8	1″.79		. .	13.7	3n

A and B (= Σ 21 App. I).

1889.10	250°.3	145″.05		. .		2n

β 1081. 37 COMÆ.

R. A. 12h 54m 32s Decl. + 31° 26′

1889.13	351°.3	5″.15	4.5	. .	13.8	3n

β 1082. 78 URSÆ MAJORIS.

R. A. 12h 55m 35s Decl. + 57° 1′

1889.17	74°.6	1″.50	6	. .	9.6	6n

β 1083. P. XII. 268.

R. A. 13h 0m 27s Decl. + 29° 40′

B and C.

1889.11	237°.3	0″.49	11.5	. .	11.7	3n

A and BC (= λ 2638)

1889.11	219°.9	6″.23	6.5	. .		3n

β 1084. W[1] XIII. 235.

R. A. 13h 15m 58s Decl. — 4° 2′

1889.31	89°.8	2″.69	7.1	. .	12.7	3n

A. $O\Sigma_2$. 12884.

R. A. 13h 20m 36s Decl. — 21° 44′

1889.37	133°.8	1″.17	8.5	. .	8.5	4n

B. A. C. 4631.

R. A. 13h 46m 32s Decl. — 35° 4′

A and B.

1889.38	84°.0	1″.28	6	. .	6	3n

A and C.

1889.38	168°.2	27″.52		. .	12	1n

A and D (= H. V.124).

1889.38	359°.0	65″.21		. .	8.5	2n

D.M. (5°) 2846.

R. A. 14h 3m 18s Decl. + 5° 14′

A and B.

1889.39	321°.9	1″.78		. .	13.7	3n

A and C.

1889.39	356°.3	53″.04	9	. .	9	3n

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TAYLOR, 6655.

R. A. 14h 12m 29s Decl. — 36° 18′

1889.39	130°.7	3″.95	7.0	.	.	12.3	3n

P. XIV. 69.

R. A. 14h 17m 29s Decl. + 9° 0′

B and C.

1889.40	135°.3	0″.19	8.4	.	.	8.4	3n

A and BC (= Σ 1835).

1889.40	189.6	6″.36	5.4	.	.		3n

LACAILLE, 5983.

R. A. 14h 26m 3s Decl. — 30° 11′

1889.41	7°.6	2″.44	6.3	.	.	11.1	6n

B. A. C. 4886.

R. A. 14h 41m 21s Decl. + 2° 32′

1889.40	137°.1	4″.54	6.2	.	.	11 8	3n

β 1085. TAYLOR 6986.

R. A. 14h 52m 34s Decl. — 4° 30′

1889.30	19°.5	9″.34	6	.	.	13.2	3n

β 1086. 47 BOOTIS.

R. A. 15h 1m 27s Decl. + 43° 37′

1889 21	256°.6	6″.03	5.5	.	.	13.2	3n

B. A. C. 5090.

R. A. 15h 21m 42s Decl. — 28° 27′

A and B.

1859.38	325°.7	0″.65	7	.	.	7.8	3n

A B and C (= h 4774).

1889.38	5°.8	9″.21		.	.	9.8	3n

β 1087. τ CORONÆ BOREALIS.

R. A. 16h 4m 35s Decl. + 36° 46′

1889.21	169°.1	3″.11	5.5	.	.	13.8	3n

LALANDE 29840.

R. A. 16h 18m 3s Decl. — 23° 11′

1889.39	26°.3	0″.90	8.1	.	.	9.2	4n

β 1088. μ DRACONIS.

R. A. 17h 2m 51s Decl. + 54° 38′

B and C.

1889.27	190°.9	12″.25		.	.	13	3n

A and B (= Σ 2130).

1889.27	159°.4	2″.40	5.5	.	.	5.6	4n

η OPHIUCHI.

R. A. 17h 3m 30s Decl. — 15° 34′

1889.39	274°.7	0″.35	3.4	.	.	3.9	4n

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B. A. C. 5820.

R. A. 17h 9m 40s Decl. — 30° 2′

1889.40	355°.8	0″.75	7.0	. .	7.6	3n

B. A. C. 5896.

R. A. 17h 21m 14s Decl. — 25° 24′

1889.14	100°.0	0″.93	7	. .	7	3n

β 1089. YARNALL 7270.

R. A. 17h 23m 22s Decl. — 5° 49′

1888.64	5°.2	0″.95	6.8	. .	11	3n

β 1090. β DRACONIS.

R. A. 17h 27m 43s Decl. + 52° 23′

1889.26	13°.4	3″.97	8	. .	14	4n

D. M. (12°) 3264.

R. A. 17h 31m 52s Decl. + 12° 37′

1889.14	240°.1	0″.71	8.5	. .	9.0	3n

Cord. Gen. Cat. 24248.

R. A. 17h 44m 38s Decl. — 28° 27′

B and C.

1889.89	175°.2	1″.31	10.4	. .	10.9	3n

A and B C.

1889.39	9°.6	6″.46	8.7	. .		3n

Wide pair noted by HOWE. Both stars in Argentine General Catalogue.

Cord. Gen. Cat. 24262.

R. A. 17h 45m 20s Decl. — 34° 42′

1889.48	212°.8	0″.58	7.4	. .	7.8	4n

67 OPHIUCHI.

R. A. 17h 54m 38s Decl. + 2° 56′

A and B.

1889.39	195°.6	6″.79	5	. .	14.8	3n

A and C (= Sh 255).

1889.40	143°.6	54″.54		. .		2n

C and D.

1889.40	129°.6	8″.40	8.8	. .	11.5	2n

68 OPHIUCHI.

R. A. 17h 55m 40s Decl. + 1° 19′

1889.39	14°.9	1″.01	5.1	. .	9.9	5n

Y. 7599.

R. A. 17h 56m 54s Decl. — 24° 15′

A and B.

1889.40	55°.6	0″.63	8.7	. .	9.5	4n

A and C (= h 5009).

1889.40	23°.3	4″.05		. .	9.6	4n

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GROOMBRIDGE 2500.

	R. A. $17^h\ 58^m\ 59^s$		Decl. $+44°\ 13'$				
1889.53	144°.7	0″.80	7.8	.	.	9.7	3n

β 1091. LALANDE 33592.

	R. A. $18^h\ 8^m\ 35^s$		Decl. $+38°\ 34'$				
1888.78	88°.1	0″.53	8.6	.	.	8.6	2n

B. A. C. 6285.

	R. A. $18^h\ 23^m\ 12^s$		Decl. $-33°\ 4'$				
1889.42	198°.6	3″.17	6.1	.	.	11.5	3n

β 1033. ν^2 SAGITTARII.

	R. A. $18^h\ 47^m\ 51^s$		Decl. $-22°\ 49'$				
1888.68	104°.0	1″.37	5.5	.	.	11	1n

GROOMBRIDGE 2829.

	R. A. $19^h\ 18^m\ 51^s$		Decl. $+52°\ 9'$				
1889.48	344°.3	0″.34	6.3	.	.	6.3	3n

9 VULPECULÆ.

	R. A. $19^h\ 29^m\ 18^s$		Decl. $+19°\ 23'$				
1889.43	31°.3	9″.53	5.5	.	.	14	3n

θ CYGNI.

	R. A. $19^h\ 33^m\ 13^s$		Decl. $+49°\ 56'$				
1889.37	43°.9	3″.62	5	.	.	14.3	3n

D. M. (26°) 3640.

	R. A. $19^h\ 38^m\ 11^s$		Decl. $+26°\ 39'$				
1889.56	227°.3	0″.49	8.3	.	.	8.7	3n

LALANDE 38224.

	R. A. $19^h\ 54^m\ 56^s$		Decl. $+31°\ 30'$				
1889.56	338°.6	0″.87	6.8	.	.	9.5	3n

RUMKER 8289.

	R. A. $20^h\ 19^m\ 29^s$		Decl. $+63°\ 36'$				
1889.48	80°.6	4″.32	5.8	.	.	12.7	3n

Not found in any other Star Catalogue except the D. M.

LALANDE 39561.

	R. A. $20^h\ 25^m\ 10^s$		Decl. $+45°\ 20'$				
1889.53	338°.3	1″.53	8.3	.	.	10.7	4n

LALANDE 39698.

	R. A. $20^h\ 28^m\ 6^s$		Decl. $+49°\ 8'$				
1889.54	206°.6	0″.35	8.1	.	.	9.7	3n

β 1034. 7 AQUARII.

	R. A. $20^h\ 50^m\ 25^s$		Decl. $-10°\ 9'$				
1888.68	165°.0	2″.09	6	.	.	11.7	5n

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B. A. C. 7278.

R. A. 20h 52m 36s Decl. + 50° 16′

1889.44	344°.3	6″.88	6	. .	13.7	3n

Lalande 40856.

R. A. 20h 58m 34s Decl. + 45° 22′

1889.44	188°.7	0″.29	7.2	. .	8.5	3n

Radcliffe 5088.

R. A. 20h 58m 39s Decl. + 56° 36′

1889.37	138°.6	1″.86	6	. .	12.5	3n

Radcliffe 5183.

R. A. 21h 14m 1s Decl. + 58° 6′

1889.56	276°.5	3″.89	6.7	. .	12.3	3n

β 1035. B. A. C. 7422.

R. A. 21h 17m 16s Decl. − 26° 4′

1888.74	198°.7	1″.05	8	. .	10.7	3n

A. Oe. 22270.

R. A. 21h 22m 7s Decl. + 57° 43′

1889.58	165°.9	2″.72	7.7	. .	13.2	3n

D. M. (56°) 2579.

R. A. 21h 25m 6s Decl. + 56° 33″

1889.59	353°.9	0″.41	8.7	. .	8.7	3n

β 1036. Yarnall 9529.

R. A. 21h 40m 59s Decl. − 17° 51′

1888 74	205°.9	4″.53	8	. .	11	3n

β 1092. Radcliffe 5777.

R. A. 22h 33m 3s Decl. + 72° 15′

A and B.

1889.30	237°.1	0″.32	7.5	. .	7.5	2n

A B and D (=H. V.94).

1889.31	137.4	42″.17	7.2	. .	7.2	3n

A B and C.

1889.31	264°.0	29″.19		. .	12.2	3n

P. xxi. 248.

R. A. 21h 35m 14s Decl. + 56° 57′

A and B.

1889.61	323°.5	1″.55	6	. .	13.7	2n

A and C (= Σ 2816).

1889.61	120°.4	11″.86		. .	7.3	3n

A and D (= Σ 2816).

1889.61	339°.5	19″.94		. .	7.3	3n

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η Pegasi.

R. A. 22h 37m 23s Decl. + 29° 36′

B and C.

1889.53	83°.3	0″.29	10.1	.	.	10.1	4n

A and B C (=H. VI.21).

1889.53	339°.0	90″.38		.	.		4n

β 1037. D. M. (12°) 4888.

R. A. 22h 41m 56s Decl. + 12° 22′

1888.81	224°.4	0″.66	8.7	.	.	10 8	3n

A. Oe. 24690.

R. A. 22h 42m 45s Decl. + 57° 55′

A and B.

1889.59	153°.0	1″.03	8.2	.	.	11.0	3n

A and C.

1889.59	179°.5	21″.99		.	.	9.5	3n

W² XXII. 971.

R. A. 22h 42m 48s Decl. + 30° 28″

1889.55	335°.3	0″.23	7.2	.	.	8.2	3n

2 Andromedæ.

R. A. 22h 57m 5s Decl. + 42° 7′

1889.54	317°.8	0″.28	5	.	.	8.7	3n

Groombridge 4070.

R. A. 23h 22m 12s Decl. + 61° 58

1889.60	78°.9	2″.13	7.1	.	.	13	3n

D. M. (57°) 2746.

R. A. 23h 24m 11s Decl. + 58° 1′

1889.58	309°.1	0″.52	9.4	.	.	9.8	

This pair is 231″ from $O\Sigma$ 496 in the direction of 207°.6

A. Oe. 25672.

R. A. 23h 24m 46s Decl. + 64° 24′

1889.60	44°.0	0″.61	8.7	.	.	9.0	3n

Anonymous.

R. A. 23h 25m 6s Decl. + 57° 43′

1889.59	298°.7	0″.64	9.7	.	.	9.7	3n

This pair is 116″.88 from Σ 3022 in the direction of 189°.7 Not in any Star Catalogue.

Groombridge 4142.

R. A. 23h 42m 17s Decl. + 68° 9′

B and C.

1889.60	102°.4	0″.64	9.2	.	.	9.2	3n

A and B C.

1889.60	136°.3	74″.28	7.5	.	.		3n

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β 1038. D. M. (41°) 4881.

R. A. 23h 45m 31s Decl. + 41° 25′

1888.73	157°.6	0″.60	8.3 . .	8.3	3n

D. M. (73°) 1068.

R. A. 23h 55m 12s Decl. + 74° 8′

1889.51	310°.1	0″.98	8 . .	8.2	3n

MICROMETRICAL MEASURES OF KNOWN DOUBLE STARS.

β CASSIOPEÆ.

R. A. 0h 42m 43s Decl. + 58° 29′

1889.59	189°.2	22″.63	2.5 . .	13.7	3n

This faint star was first noted, I think, by Mr. Alvan G. Clark.

β 253.

R. A. 0h 4m 5s Decl. + 57° 51′

1889.28	50°.8	0″.65	8.3 . .	8.3	3n

β 485.

R. A. 0h 4m 30s Decl. + 58° 6′

1889.55	307°.4	0″.44	8.5 . .	8.6	3n

β 486. CETI 33.

R. A. 0h 8m 19s Decl. — 8° 27′

1888.91	5°.3	3″.09	5 . .	11	1n

Σ 13.

R. A. 0h 9m 25s Decl. + 76° 17′

1889.41	91°.7	0″.81	6.2 . .	6.3	4u

β 392. B. A. C. 46.

R. A. 0h 10m 31s Decl. + 60° 52′

1888.71	68°.2	19″.18	6.5 . .	12.3	3n

β 395. B. A. C. 160.

R. A. 0h 31m 9s Decl. — 25° 26′

1888.91	112°.4	0″.98	. .		1n

β 491. δ ANDROMEDÆ.

R. A. 0h 32m 54s Decl. + 30° 12′

1888.71	299°.7	27″.60	3 . .	12.5	3n

α CASSIOPEÆ

R. A. 0h 33m 42s Decl. + 55° 53′

A and B.

1889.60	272°.4	17″.56	2 . .	14.5	3n

A and C.

1889.60	106°.5	39″.72	. .	14	3n

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A and D (= h 1993).

1889.60	280°.2	63″.20		. .	9	3n

β 231. o CASSIOPEÆ.

R. A. 0h 38m 2s Decl. + 47° 38′

1888.71	303°.5	32″.63		. .	11.6	3n

β 492. B. A. C. 201.

R. A. 0h 38m 28s Decl. + 54° 34′

1889.55	152°.7	2″.11	5.7	. .	11.3	3n

β 1.

R. A. 0h 45m 45s Decl. + 55° 58′

A and B.

1889.55	82°.6	1″.45	8.2	. .	9.8	3n

A and C.

1889.55	134°.2	3″.82		. .	8.7	3n

A and D.

1889.55	193°.7	8″.97		. .	8.7	3n

A and E.

1889.55	333°.1	15″.84		. .	12.5	3n

β 734.

R. A. 0h 46m 47s Decl. — 24° 39′

1888.84	346°.9	10″.83	7	. .	10	2n

β 396. B. A. C. 282.

R. A. 0h 56m 13s Decl. + 60° 26′

1888.72	66°.8	1″.25	6.3	. .	9.3	4n
1889.53	66°.4	1″.28	6.0	. .	10	3n

β 235.

R. A. 1h 3m 27s Decl. + 50° 22′

1889.53	86°.1	0″.79	7.2	. .	7.3	3n

β 258.

R. A. 1h 5m 29s Decl. + 61° 4′

1889.57	268°.2	0″.99	6.3	. .	9.7	3n

POLARIS.

R. A. 1h 13m 45s Decl. + 88° 40′

1889.29. Both stars single with 36-inch, and no near companion seen.

β 999. ω ANDROMEDÆ.

R. A. 1h 20m 27s Decl. + 44° 47′

A and B.

1888.70	95°.4	2″.64	6	. .	11.8	3n

A and C.

1888.75	110°.3	132″.49		. .		3n

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C and D.

1888.75	137°.9	4″.96	10.2	. .	10.2	3n

β 506. η PISCIUM.

R. A. 1h 25m 4s Decl. + 14° 44′

1888.73	16°.5	1″.10	4	. .	10	3n

β 305. PERSEI 58.

R. A. 1h 30m 52s Decl. + 37° 13′

1888.71	205°.5	20″.78	7	. .	10.7	2n

β 513 48 CASSIOPEÆ.

R. A. 1h 52m 7s Decl. + 70° 19′

1888.70	298°.1	0″.83	5	. .	6.3	4n
1889.52	304°.4	0″.76	5	. .	9	3n

Binary in rapid motion.

β 785. 49 CASSIOPEÆ.

R. A. 1h 54m 4s Decl. + 75° 32′

1889.52	243°.7	5″.40	5.1	. .	13.2	3n

$O\Sigma$ 38. γ ANDROMEDÆ.

R. A. 1h 56m 32s Decl. + 41° 45′

1888.600. Only a slight elongation in the direction of 120° with 2700 on the 36-inch.

1889.515	98°.2	0″.09		. .		1n

Σ 279.

R. A. 2h 28m 15s Decl. + 36° 47′

1888.71	70.3	17″.78	6.9	. .	10.7	2n

β 524. 20 PERSEI.

R. A. 2h 46m 9s Decl. + 37° 51′

A and B.

1888.68	83°.9	0″.23	6	. .	6	1n
1889.59	291°.3	0″.17	5.5	. .	6	1n

A B and C (= Σ 318).

1888.68	236°.7	13″.80		. .	9	1n

A. C. 2. 95 CETI.

R. A. 3h 12m 12s Decl. — 1° 22′

1888.77	112°.8	0″.45	6	. .	8.5	2n

Σ 412. 7 TAURI.

R. A. 3h 27m 20s Decl. 24° 4′

A and B.

A B and C.

β 535 38 PERSEI.

R. A. 3h 36m 47s Decl. + 31° 54′

1888.71	59°.2	1″.09		. .		3n

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β 547. 47 TAURI.

R. A. $4^h\ 7^m\ 25^s$ Decl. $+8°\ 58'$

1888.81	359°.7	0″.91	5.7	. .	8.8	3n

Σ 518. 40 ERIDANI.

R. A. $4^h\ 9^m\ 52^s$ Decl. $-7°\ 47'$

B and C.

1888.84	106°.8	2″.04		. .		8n

A and B.

1888.84	105°.5	82″.15		. .		2n

Σ 566. 2 CAMELOPARDI.

R. A. $4^h\ 30^m\ 27^s$ Decl. $+58°\ 14'$

A and B.

1888.92	291°.9	1″.58		. .		8n

A and C.

1888.92	209°.8	23″.66		. .	13.2	8n

β 814. LEPORIS 3.

R. A. $4^h\ 53^m\ 39^s$ Decl. $-16°\ 34'$

A and B.

1889.13	326°.9	1″.05	6.5	. .	8.3	3n

A and C.

1889.13	29°.0	54″.45		. .	8.2	2n

β 555. β ORIONIS.

R. A. $5^h\ 8^m\ 47^s$ Decl. $-8°\ 20'$

B and C.

1889.093. No certain elongation.

Σ 719.

R. A. $5^h\ 22^m\ 27^s$ Decl. $+29°\ 27'$

A and B.

1889.10	334°.6	1″.03	6.5	. .	9	1n

A and C.

1889.10	351°.4	15″.16		. .	8.5	1n

Σ 728. 32 ORIONIS.

R. A. $5^h\ 24^m\ 22^s$ Decl. $+5°\ 51'$

1889.03	179°.2	0″.38	4.7	. .	6	8n

θ ORIONIS.

R. A. $5^h\ 29^m\ 23^s$ Decl. $-5°\ 28'$

A and B.

1888.88	32°.3	8″.74		. .		8n

A and C.

1888.88	131°.3	12″.95		. .		8n

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D and C.

1888.87	240°.6	13″.35	. .			3n

D and B.

1888.88	299°.5	19″.89	. .			3n

B and C.

1888.88	163°.0	16″.76	. .			3n

A and D.

1888.88	95°.4	21″.55	. .			3n

A and E (Fifth Star).

1888.88	351°.5	4″.81	. .			3n

C and F (Sixth Star).

1888.86	120°.9	3″.99	. .			3n

C and G (A. G. Clark's star).

1888.98	33°.9	7″.40	. .	16		4n

D and G.

1888.98	270°.5	7″.03	. .			4n

A and H (Barnard's star).

1889.00	178°.4	7″.94	. .	16		2n

C and H.

1889.02	275°.6	8″.62	. .			3n

H^1 and H^2 (Barnard's pair).

1889.07	274°.0	1″.82	16	. .	16.5	1n

S. 503.

R. A. 5h 49m 10s Decl. + 13° 56′

A and B.

1889.11	8°.6	3″.36	7	. .	8	3n

A and C.

1889.11	163°.2	20″.92		. .	10.8	3n

β 1008. η Geminorum.

R. A. 6h 7m 38s Decl. + 22° 32′

1889.14	294°.8	1″.04	8	. .	10.5	3n

A. G. C. 1. Sirius.

R. A. 6h 39m 53s Decl. — 16° 33′

1888.97	13°.9	5″.27		. .		5n

Procyon.

R. A. 7h 38m 1s Decl. + 5° 33′

1888.82 Carefully examined with the 36-inch. Nothing nearer than the old companion.

β 580.

R. A. 7h 38m 1s Decl. + 28° 19′

1889.14	130°.9	1″.14	9.5	. .	12.5	1n

This is one of the distant companions to Pollux.

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β 101. 9 ARGUS.

R. A. $7^h\ 46^m\ 13^s$ Decl. $-18°\ 35'$

1889.08	76°.4	0″.34	5.7 . .	6.8	4n

Σ 1196. ζ CANCRI.

R. A. $8^h\ 5^m\ 20^s$ Decl. $+18°\ 1'$

1888.29. No other component seen.

β 208.

R. A. $8^h\ 33^m\ 54^s$ Decl. $-22°\ 16'$

1889.15	47°.5	1″.06	7 . .	8	2n

Σ 1273. ε HYDRÆ.

R. A. $8^h\ 40^m\ 25^s$ Decl. $+6°\ 52'$

A and B (Perrotin).

1889.98	154°.4	0″.26	4 . .	6	2n

A B and C.

1889.08	226°.5	3″.16	. .		3n

A B and D.

1889.22	193°.8	19″.68	. .		2n

PERROTIN.

R. A. $8^h\ 44^m\ 49^s$ Decl. $+8°\ 47'$

1889.12	350°.1	0″.95	7.9 . .	8.6	3n

$\varkappa$ CANCRI.

R. A. $9^h\ 1^m$ Decl. $+11°\ 10'$

1889.13. No indication of duplicity.

β 105. $\varkappa$ LEONIS.

R. A. $9^h\ 17^m\ 40^s$ Decl. $+26°\ 42'$

1889.13	203°.9	2″.79	4.5 . .	10.9	3n

JACOB 5.

R. A. $9^h\ 25^m\ 26^s$ Decl. $-28°\ 14'$

1889.24	248°.8	1″.05	6.3 . .	7.1	3n

0Σ 521. υ URSÆ MAJORIS.

R. A. $9^h\ 42^m\ 30^s$ Decl. $+59°\ 36'$

1889.18	294°.5	11″.23	5 . .	12.5	3n

A. C. 5. 8 SEXTANTIS.

R. A. $9^h\ 46^m\ 34^s$ Decl. $-7°\ 32'$

1889.17	125°.6	0″.54	5.5 . .	6	3n

Σ 1424. γ LEONIS.

R. A. $10^h\ 13^m\ 20^s$ Decl. $+20°\ 27'$

1889.29	114°.6	3″.51	. .		3n

β 599. 65 LEONIS.

R. A. $11^h\ 1^m\ 50^s$ Decl. $+2°\ 30'$

1889.27	88°.5	1″.78	5.6 . .	10.5	3n

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β 916. CRATERIS 31.

R. A. 11h 8m 13s Decl. — 14° 47′

1889.25	0°.2	0″.88	7.5	. .	8.3	3n

h 4478. β HYDRÆ.

R. A. 11h 46m 51s Decl. — 33° 14′

1889.43	349°.6	1″.53		. .		3n

β 607.

R. A. 12h 35m 2s Decl. — 0° 48′

1889.31	316°.3	1″.20	9	. .	10	3n

Σ 1670. γ VIRGINIS.

R. A. 12h 35m 37s Decl. — 0° 47′

A and B.

1889.31	153°.4	5″.72		. .		3n

A and C.

1889.30	159°.4	53″.12		. .	14.5	3n

β 609.

R. A. 13h 4m 28s Decl. — 4° 18′

1889.31	349°.1	0″.91	6.8	. .	9.8	3n

β 935. 86 VIRGINIS.

R. A. 13h 39m 33s Decl. — 11° 49′

A and B.

1889.30	299°.6	1″.66	5.8	. .	10	3n

C and D.

1889.30	275°.9	2″.24	10.5	. .	11.2	3n

A and C (= Σ 1780 rej.)

1889.30	164°.6	27″.17		. .		3n

β 413.

R. A. 13h 42m 15s Decl. — 27° 46′

1889.39	109°.5	77″.66	7.7	. .	9.2	3n

β 843. CENTAURI 219.

R. A. 13h 45m 8s Decl. — 31° 1′

1889.37	129°.7	1″.70	6.2	. .	7.1	4n

β 614.

R. A. 13h 48m 2s Decl. + 10° 44′

1889.40	271°.1	0″.44	7.8	. .	11.2	3n

SWIFT.

R. A. 13h 57m 40s Decl. + 46° 55′

1889.39	6°.7	2″.44	9	. .	9	2n

β 940. 52 HYDRÆ.

R. A. 14h 21m 9s Decl. — 28° 57′

1889.38	278°.7	4″.27		. .	10.8	3n

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β 414. CENTAURI 315.

R. A. $14^h\ 34^m\ 42^s$ Decl. $-30°\ 25'$

1889.43	345°.6	1″.01	6.5	. .	7.9	3n

HOLDEN. 5 LIBRÆ.

R. A. $14^h\ 39^m\ 21^s$ Decl. $-14°\ 57'$

1889.38	249°.2	2″.79	6.2	. .	11.3	3n

β 106. μ LIBRÆ.

R. A. $14^h\ 42^m\ 45^s$ Decl. $-13°\ 39'$

A and B.

1889.38	340°.6	1″.61	5	. .	6	3n

A and C.

1889.38	283°.7	18″.38		. .	14.5	3n

A and D.

1889.38	185°.5	25″.96		. .	13.9	3n

A and E.

1889.38	232°.5	27″.19		. .	12.8	3n

β 447.

R. A. $14^h\ 47^m\ 18^s$ Decl. $-32°\ 49'$

A and B.

1889.45	320°.5	13″.01	6.5	. .	10.5	3n

A and C.

1889.45	243°.1	58″.46		. .	9.8	3n

β 239. 59 HYDRÆ.

R. A. $14^h\ 51^m\ 23^s$ Decl. $-27°\ 10'$

1889.44	311°.4	0″.86	5.8	. .	5.9	3n

β 348. 2 SERPENTIS.

R. A. $14^h\ 55^m\ 40^s$ Decl. $+0°\ 20'$

1889.31	119°.0	0″.76	6	. .	6.7	2n

Σ 1926.

R. A. $15^h\ 10^m\ 23^s$ Decl. $+38°\ 45'$

1889.35	257°.7	1″.10	7.7	. .	9.2	3n

β 948.

R. A. $15^h\ 12^m\ 16^s$ Decl. $+1°\ 23'$

1889.30	92°.7	2″.68	6.2	. .	12.3	3n

β 32. 6 SERPENTIS.

R. A. $15^h\ 14^m\ 54^s$ Decl. $+1°\ 9'$

1889.30	17°.9	2″.44	5.8	. .	10	3n

β 121. B. A. C. 5163.

R. A. $15^h\ 32^m\ 20^s$ Decl. $-27°\ 15'$

1889.47	277°.5	1″.45	8.2	. .	8.2	3n

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β 947. β Scorpii.

R. A. 15h 58m 28s Decl. — 19° 29′

A and B.

1889.41	98°.9	0″.94	. .	10.8	5n

β 811.

R. A. 16h 0m 26s Decl. + 22° 18′

1889.49	220°.7	3″.70	7.8	. .	10.8	3n

β 120. ν Scorpii.

R. A. 16h 5m 1s Decl. — 19° 9′

1889.44	1°.2	0″.80	. .		3n

Sh. 228. ρ Ophiuchi.

R. A. 16h 18m 23s Decl. — 23° 10′

A and B.

1889.39	355°.0	3″.41	5.5	. .	5.8	3n

A and C.

1889.39	359°.8	151.15″		. .	8	2n

A and D.

1889.39	253°.0	156″.43		. .	8	3n

D, as a close pair, is given in the list of new doubles.

β 815.

R. A. 16h 28m 16s Decl. + 43° 11′

1889.43	343°.3	7″.68	8.5	. .	10.8	3n

β 818. 32 Herculis.

R. A. 16h 28m 50s Decl. + 30° 45′

1889.28	32°.9	3″.64	6	. .	13.5	3n

Kustner.

R. A. 16h 48m 27s Decl. + 77° 43′

1889.21	189°.3	2″.72	7	. .	10.3	3n

Σ 2118. 20 Draconis.

R. A. 16h 55m 49s Decl. + 65° 13′

1889.45	140°.7	0″.11	5.5	. .	6	3n

β 823.

R. A. 17h 0m 29s Decl. + 0° 49′

1889.48	359°.8	1″.17	8.3	. .	9.5	3n

β 125.

R. A. 17h 4m 43s Decl. — 26° 53′

1889.47	61°.3	1″.48	7.9	. .	10	3n

β 282.

R. A. 17h 8m 29s Decl. — 14° 27′

1889.42	151°.9	4″.31	6.3	. .	11.3	3n

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β 957.

R. A. 17h 8m 57s Decl. — 10° 10′

1889.50	201°.7	0″.47	8.2	. .	8.4	3n

α HERCULIS.

R. A. 17h 9m 10s Decl. + 14° 32′

A and C.

1888.49	335°.8	23″.54		. .	15	2n

β 416.

R. A. 17h 10m 47s Decl. — 34° 51′

A and B.

1889.25	137°.4	1″.48	6.3	. .	7.5	4n

A B and C (= h 4935).

1889.43	128°.6	31″.03		. .	10.5	3n

SWIFT.

R. A. 17h 15m Decl. + 53° 47′

1889.43	132°.0	0″.57	8.9	. .	9.0	3n

β 962. 26 DRACONIS.

R. A. 17h 33m 44s Decl. + 61° 58′

1889.42	180°.1	0″.95	4.7	. .	11	4n

A. C. 7. μ HERCULIS.

R. A. 17h 41m 47s Decl. + 27° 48′

B and C.

1889.51	357°.9	0″.55	10	. .	10.1	4n

β 633. γ DRACONIS.

R. A. 17h 53m 49s Decl. + 51° 30′

1889.25	151°.3	21″.10		. .	12.5	3n

Σ 2268.

R. A. 17h 58m 20s Decl. + 25° 22′

A and B (= β 825.)

1889.47	194°.6	11″.20		. .	11.3	3n

A and C (= Σ 2268).

1889.47	211°.6	20″.00	8.5	. .	8.8	4n

Σ 2272. 70 OPHIUCHI.

R. A. 17h 59m 28s Decl. + 2° 33′

A and B.

1889.30	348°.7	2″.16		. .		2n

A and C.

1889.30	203°.3	59″.45		. .	12.7	2n

A and D.

1889.30	43°.2	95″.17		. .	12.2	2n

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O Σ 342. 72 Ophiuchi.

R. A. 18h 1m 42s Decl. + 9° 33′

1889.30 Large star single.

A. C. 15. 99 Herculis.

R. A. 18h 2m 28s Decl. + 30° 33′

1889.50	281°.2	0″.65	6	. .	11.5	1n

β 759.

R. A. 18h 3m 54s Decl. — 39° 32′

A and B.

1889.40	121°.4	1″.81	8.9	. .	9.1	3n

A and C (= *h* 5028.)

1889.40	147°.3	14″.92		. .	9.0	3n

β 760. *η* Sagittarii.

R. A. 18h 9m 31s Decl. — 36° 48′

A and B.

1889.41	107°.0	3″.51		. .	11.4	4n

A and C.

1889.41	302°.8	93″.22		. .	10	2n

OΣ 357.

R. A. 18h 30m 21s Decl. + 11° 37′

1889.21	72°.8	0″.43	8.2	. .	8.2	3n

ζ Lyrae.

R. A. 18h 40m 38s Decl. + 37° 29′

A and B (new).

1889.43	48°.7	26″.98		. .	15.7	2n

A and C (= *Σ* 28 App. I).

1889.43	149°.3	43″.73		. .		2n

Σ 2400.

R. A. 18h 43m 32s Decl. + 16° 7′

A and B (Perrotin).

1889.47	189°.0	1″.61	8.2	. .	11.1	4n

A and C (*Σ* 2400).

1889.47	191°.7	2″.54		. .	11.0	4n

B and C.

1889.48	17°.5	0″.81		. .		2n

Σ 3180.

R. A. 18h 52m 20s Decl. + 44° 4′

1889.46 Large star single, with all powers to 1900.

ζ Sagittarii.

R. A. 18h 55m 0s Decl. — 30° 3′

1888.62	257°.4	0″.70		. .		6n
1889.41	255°.1	0″.81		. .		5n

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Σ 2438.

R. A. 18h 55m 29s Decl. + 58° 4′

1889.46	46°.2	0″.24	7.2	. .	7.3	3n

γ CORONAE AUSTRALIS.

R. A. 18h 58m 18s Decl. — 37° 14′

1889.41	185°.4	1″.79	5.5	. .	5.5	4n

β 287. ζ AQUILAE.

R. A. 18h 59m 54s Decl. + 13° 41′

1889.43	57°.3	5″.63		. .	13	3n

β 654. 52 SAGITTARII.

R. A. 19h 29m 24s Decl. — 25° 10′

1889.42	159°.1	3″.00	5.1	. .	11.5	4n

β 761.

R. A. 19h 31m 45s Decl. — 39° 42′

1889.42	198°.2	2″.45	7.7	. .	10.2	3n

KUSTNER.

R. A. 19h 35m 38s Decl. + 71° 20′

1889.27	271°.1	1″.44	7.2	. .	9.2	3n

$O\Sigma$ 380. χ AQUILAE.

R. A. 19h 36m 55s Decl. + 11° 33′

1889.59 Certainly no third star.

β 658. B. A. C. 6762.

R. A. 19h 39m 1s Decl. + 26° 50′

1889.56	299°.9	0″.50	6.7	. .	9.7	3n

A. C. 9 ζ SAGITTAE.

R. A. 19h 43m 39s Decl. + 18° 51′

1889.57	5°.0	0″.12	4	. .	4.5	2n

β 980. η CYGNI.

R. A. 19h 51m 48s Decl. + 34° 46′

A and B.

1889.51	210°.4	7″.21	4	. .	13	4n

A and C.

1889.51	326°.2	46″.08		. .	11	2n

A and D.

1889.51	169°.1	49″.82		. .	10.7	2n

Ho. 121.

R. A. 20h 7m 25s Decl. + 34° 7′

A and B.

1889.43	17°.5	22″.42	7.3	. .	10.8	3n

A and C.

1889.43	14°.5	41″.56		. .	12	2n

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α^2 CAPRICORNI.

R. A. 20h 11m 24s Decl. — 12° 55′

B and C (A. G. Clark).

1889.48	239°.0	1″.19	11.3	. .	11.5	3n

A and B (= h 608).

1889.48	146°.8	7″.75		. .		3n

BARNARD. β^1 CAPRICORNI.

R. A. 20h 14m 2s Decl. — 15° 10′

1888.66	105°.9	0″.84		. .		4n

β 431.

R. A. 20h 15m 25s Decl. + 35° 53′

1889.53	38°.2	0″.66	8.6	. .	8.6	4n

β 763. χ^2 SAGITTARII.

R. A. 20h 15m 45s Decl. — 42° 48′

1889.47	211°.2	1″.336		. .	8.9	4n

β 151. β DELPHINI.

R. A. 20h 31m 55s Decl. + 14° 11′

A and B.

1888.65	310°.1	0″.29		. .		7n
1889.50	314°.2	0″.31		. .		5n

A and C.

1888.82	115°.7	26″.77		. .		2n

A and D (= Σ 2704).

1888.82	333°.2	36″.35		. .		2n

Ho. 137.

R. A. 20h 53m 37s Decl. + 29° 23′

1888.75	273°.5	0″.88	7	. .	10	2n

β 675. 51 CYGNI.

R. A. 20h 38m 31s Decl. + 49° 54′

1889.45	101″.5	2″.99	5	. .	13.2	3n

61 CYGNI.

R. A. 21h 1m 14s Decl. + 38° 8′

1889.48 Both stars single.

β 679.

R. A. 21h 1m 25s Decl. + 43° 12′

1889.45	65°.6	0″.52	10	. .	10	3n

Ho. 149.

R. A. 21h 1m 26s Decl. — 12° 10′

1888.72	326°.8	0″.90	8.2	. .	8.7	4n

KNOTT. γ EQUULEI.

R. A. 21h 4m 30s Decl. + 9° 39′

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A and B.

1888.82	275°.4	2″.14		. .		3n

A and C.

1888.82	9°.2	43″.33		. .		3n

β 159.

R. A. 21h 6m 21s Decl. + 47° 12′

A and B.

1889.53	316°.7	1″.28	7.1	. .	9.7	3n

A and C.

1889.53	189°.4	134″.16		. .	7.3	2n

Ho. 152.

R. A. 21h 7m 20s Decl. + 27° 51′

1888.75	328°.9	0″.70	8.6	. .	9.2	2n

$O\Sigma$ 535. δ Equulei.

R. A. 21h 8m 38s Decl. + 9° 31′

1888.69	189°.9	0″.25		. .		4n
1889.51	343°.2	0″.10 ±		. .		1n

A. G. Clark. τ Cygni.

R. A. 21h 10m 0s Decl. + 37° 32′

A and B.

1889.49	36°.5	0″.50		. .	10	4n

A and C.

1889.32	246°.7	19″.33		. .	13.2	2n

β 766. θ^2 Microscop.

R. A. 21h 16m 49s Decl. — 41° 31′

1889.43	307°.1	1″.06	5	. .	7	1n

β 989. χ Pegasi.

R. A. 21h 39m 12s Decl. + 25° 6′

A and B.

1888.78	274°.7	0″.23		. .		3n
1889.51	262°.3	0″.14	4.3	. .	5	4n

A B and C (= Σ 2824).

1888.82	300°.7	12″.22		. .		2n

β 690. μ Cephei.

R. A. 21h 39m 50s Decl. + 58° 14′

1889.52	259°.6	19″.58	6	. .	13.2	3n

β 276. η Piscis Aust.

R. A. 21h 53m 57s Decl. — 29° 2′

1888.78	118°.5	1″.61		. .		4n

β 290. 34 Pegasi.

R. A. 22h 20m 30s Decl. + 3° 47′

1889.58	218°.6	2″.85	6	. .	12	1n

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β 291.

R. A. 22h 21m 39s Decl. + 3° 55′

1889.59	165°.0	0″.40	8 . .	8.5	1n

β 174.

R. A. 22h 22m 58s Decl. — 10° 17′

1888.77	291°.7	8″.62	8.3 . .	10.7	3n

Σ 2912. 37 Pegasi.

R. A. 22h 23m 54s Decl. + 3° 49′

1889.59 Apparently single.

β 703. α Lacertæ.

R. A. 22h 26m 20s Decl. + 49° 40′

1888.71	297°.8	31″.59	. .	12.2	3n

β 77.

R. A. 22h 27m 51s Decl. — 2° 24′

A and B.

1888.75	213°.3	2″.77	8.5 . .	8.7	3n

A and C.

1888.75	225°.6	28″.80	. .	11	3n

β 451. 15 Lacertæ.

R. A. 22 h 46m 37s Decl. + 42° 40′

1888.71	128°.5	29″.60	5 . .	12	3n

$O\Sigma$ 482.

R. A. 22h 47m 55s Decl. + 82° 31′

1889.31	35°.9	3″.40	5.2 . .	10.7	3n

β 382. B. A. C. 7983.

R. A. 22h 48m 18s Decl. + 44° 7′

A and B.

1889.53	217°.6	0″.98	7.3 . .	8.8	3n

A and C.

1889.53	353°.7	26″.92	. .	10	2n

Σ 2959.

R. A. 22h 50m 55s Decl. — 3° 53′

1889.73	102°.7	13″.37	7 . .	8.5	2n

Barnard. 2 Piscium.

R. A. 22h 53m 18s Decl. + 0° 19′

1889.57	93°.6	3″.81	6 . .	13.7	3n

β 80.

R. A. 23h 12m 42s Decl. + 4° 45′

1888.71	319°.5	0″.92	8.2 . .	8.9	4n

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Ho. 199. 95 Aquarii.

	R. A. $23^h\ 12^m\ 43^s$		Decl. $-10°\ 16'$			
1888.72	222°.8	1″.22	4	. .	11.5	3n

β 718. 64 Pegasi.

	R. A. $23^h\ 16^m\ 3^s$		Decl. $+31°\ 9'$			
1888.80	85°.4	0″.67	5.8	. .	7.8	4n
1889.50	86°.2	0″.69	5.8	. .	8.8	3n

β 386. B. A. C. 8173.

	R. A. $23^h\ 21^m\ 12^s$		Decl. $+70°\ 1'$			
1888.71	313°.1	20″.69	7.2	. .	11.2	3n

Ho. 200.

	R. A. $23^h\ 24^m\ 19^s$		Decl. $+85°\ 45'$			
1889.31	142°.6	2″.38	6.6	. .	10.6	3n

$\cdot 0\Sigma$ 496.

	R. A. $23^h\ 24^m\ 29^s$		Decl. $+57°\ 53'$			
	A and B.					
1889.58	342°.1	1″.28	6	. .	11.5	3n
	C and D.					
1889.58	224°.1	1″.51	7.5	. .	8.6	3n
	A and C.					
1889.59	269°.0	75″.53		. .		2n

Σ 3022.

	R. A. $23^h\ 25^m\ 7^s$		Decl. $+57°\ 45'$			
1889.58	226°.3	20″.36	8.6	. .	9.1	3n

β 720. 72 Pegasi.

	R. A. $23^h\ 28^m\ 0^s$		Decl. $+30°\ 40'$			
1889.50	146°.0	0″.38	6	. .	6	3n

β 279. ω^3 Aquarii.

	R. A. $23^h\ 36^m\ 30^s$		Decl. $-15°\ 12'$			
1888.71	83°.3	5″.86	5.2	. .	11	3n

A. G. C. 14. 78 Pegasi.

	R. A. $23^h\ 37^m\ 57^s$		Decl. $+28°\ 42'$			
1889.48	197°.0	1″.44	5.5	. .	9.7	3n

Barnard. W[1] xxiii, 803.

	R. A. $23^h\ 40^m\ 53^s$		Decl. $+4°\ 35'$			
1889.57	166°.2	0″.54	8.6	. .	8.6	3n

β 995.

	R. A. $23^h\ 41^m\ 35^s$		Decl. $+46°\ 10'$			
1889.48	243°.4	0″.93	6.2	. .	10.2	3n

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β 996.

R. A. 23h 46m 31s Decl. + 74° 53′

1888.74	67°.1	5″.43	7.2	.	.	12	3n
1889.51	68°.0	5″.77	6.4	.	.	12.5	3n

β 730. 27 Piscium.

R. A. 23h 52m 32s Decl. — 4° 13′

1889.57	267°.4	1″.50	5	.	.	11.3	3n

β 733. 85 Pegasi.

R. A. 23h 55m 52s Decl. + 26° 27′

A and B.

1888.69	126°.7	0″.95		.	.		5n
1889.							

A and C.

1888.67	0°.9	21″.71		.	.		5n
1889.50	358°.7	22″.66		.	.	9	4n

A and D.

1888.69	283°.8	72″.02					1n

β 482.

R. A. 23h 56m 44s Decl. + 62° 39′

A and B.

1888.71	343°.8	4″.60	9	.	.	10	3n

A and C.

1888.71	123°.9	9″.79		.	.	11.2	3n

Σ 3057.

R. A. 23h 58m 43s Decl. + 57° 52′

1889.57	120°.1	3″.66	6.9	.	.	9.1	3n

Σ 3062.

R. A. 23h 59m 57s Decl. + 57° 46′

1889.57	321°.1	1″.45	6.5	.	.	7.5	3n

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ERRORS IN STAR CATALOGUES. By Prof. E. FRISBY, Washington, D. C.

THE NEW DEARBORN OBSERVATORY. By Prof. G. W. HOUGH, Northwestern University, Evanston, Ill.

ANNUAL PARALLAX OF SOUTH 503. By Prof. F. P. LEAVENWORTH, Haverford College, Pa.

THE SOLAR CORONA, A PHENOMENON IN SPHERICAL HARMONICS. By Prof. FRANK H. BIGELOW, Nautical Almanac Office, Washington, D. C.

FORMULA FOR THE PROBABILITY OF ANY FACT OR OCCURRENCE ABOUT WHICH ANY NUMBER OF WITNESSES MAY TESTIFY. By J. E. HENDRICKS, Des Moines, Ia.

METHOD OF FINDING FACTORS. By JAMES D. WARNER, Brooklyn, N. Y.

DRAFT OF A MEMORIAL RELATIVE TO UNIVERSAL TIME. By C. CARPMAEL, President of the Canadian Institute, and A. MACDOUGALL, Toronto, Can.

[After discussion in the section, this memorial was referred to the Council, and a special committee was appointed to report at the meeting of 1896.]

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SECTION B.

PHYSICS.

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ADDRESS

BY

PROFESSOR HENRY S. CARHART,

VICE PRESIDENT, SECTION B.

REVIEW OF THEORIES OF ELECTRICAL ACTION.

THE Physics Section of this Association congratulates itself because it deals with topics of the most lively interest, not only from a practical point of view but still more from a theoretical one. Even popular interest in electricity is now well-nigh universal. Its applications increase with such prodigious rapidity that only experts can keep pace with them. At the same time the developments in pure electrical theory are such as to astound the intelligent layman and to inflame the imagination of the most profound philosopher.

Of the practical applications of electricity it is not necessary to speak. They bear witness of themselves. A million electric lamps nightly make more splendid the lustrous name of Faraday; a million messages daily over land and under sea serve to emphasize the value of Joseph Henry's contribution to modern civilization. Blot out these two names alone from the galaxy of stars that shine in the physical firmament, take from the world the benefits of their investigations, and the civilization of the present would become impossible. The value of the purely scientific work of such men is attested by the resulting well-being, comfort and happiness of mankind.

But the mind can never rest satisfied with the facts and applications of a science however interesting and useful they may be. It feels an inward impulse to link the facts into a related whole, to inquire into their causes, to frame a satisfactory theory of their

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correlation, and so to build on them a true science. It is, indeed, interesting to study the history of any scientific doctrine and to trace its development from the crude notions of its earliest stages to the more refined conceptions of later periods, comporting indefinitely better with the marvelous processes of nature. Such a history we have in the views which have been held regarding the nature and action of electricity. The transition from the glutinous effluvium of the sagacious Robert Boyle to the magnetic and electric waves of the present, traversing the omnipresent ether with the velocity of light, is not an easy one to make even in a period of two hundred years. For more than twenty centuries natural philosophers had nothing better than the emission theory to account for the attraction exhibited by rubbed amber and other similar substances. Their notion was that the rubbing of the amber caused it to emit an effluvium which returned again to its source and carried light bodies back with it.

In one respect this fanciful attempt to explain electrical action deserves commendation; for it evinces a mental inaptitude to account for physical action "at a distance," or without some intermediate agency. Later philosophers, satisfied perhaps too easily with mathematical explanations founded on the observed laws of attraction and repulsion and not demanding a medium, did not feel the same intellectual necessity of filling the space between bodies acting on one another, either with emanations from those bodies, or with an invisible, imponderable medium, suspected by no sense of man but required only to meet a demand of his highest intelligence. For when the Newtonian philosophy had made some progress the doctrine of unctuous effluvia was given up, and physicists acquiesced in the unexplained principle of attraction and repulsion as properties of bodies communicated to them by the Divine Being, the mechanism of which they scarcely attempted to explain (Priestley). "Many superficial philosophers thought they had given a very good account of electricity, cohesion and magnetism by calling them particular species of attraction peculiar to certain bodies."[1]

The discovery of Stephen Grey that the "electric virtue" could be conveyed along a wire for several hundred feet without sensible diminution, and the invention of the Leyden jar by Kleist or Cuneus, had the effect of annihilating many mushroom theories con-

[1] Priestley's Hist. of Elect., Vol. 2, p. 18.

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structed on the slimmest basis of facts. The latter discovery disclosed a power in electricity not previously suspected, and excited the greatest interest both in Europe and America. At this period Franklin turned his attention to the subject, and "spent more time in diversifying facts and less in refining upon theory" than some of his European contemporaries. In fact, he tells us that he was never before engaged in any study that so totally engrossed his attention and his time.

His discovery that the two electricities are always excited in equal quantities, that the charge resides on the glass and not on the coatings of the Leyden jar, and his experimental identification of lightning with frictional electricity excited the liveliest interest abroad and secured for him the Copley medal of the Royal Society; while his theory of positive and negative electricity made a permanent addition to the nomenclature of the science. His conceit that a turkey, killed with the discharge of a battery of jars, was uncommonly tender eating, a discovery gravely communicated to the Royal Society by William Watson, is not so well known and does not appear up to the present to have been verified.

We cannot agree with him, I am sure, when he says, "nor is it of much importance for us to know the manner in which nature executes her laws; it is enough if we know the laws themselves." For the pursuit of the manner in which nature executes her laws is the distinguishing characteristic of the science of the present day. It has led to most brilliant discoveries, and it bids fair to do more than all other agencies combined to show the intimate and necessary relations existing between the different branches of physics. We need to be reminded often that accumulated facts do not constitute a science, and that utility is not the highest reward of scientific pursuits. A bit of polished marble plucked from the ruins of the Roman Palatine Hill is an interesting relic; but how much more interesting to reconstruct the palace of Nero and to see this fluted marble in its proper and designed relation to the whole of which it was once a necessary part! Science is constructive. Laws are derived from an attentive consideration of facts; generalizations group laws under broader relationships; and great principles unite all together into one related, impressive whole.

From the time when the famous Boyle caught sight of a faint glimmer of electric light to the present, physicists have been in pursuit of the connection between light and electricity. As early

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as Newton's time, the ether was conceived by some to be a very subtle medium confined to small distances from the surfaces of bodies and to be the chief agent in all electrical phenomena. But, says Priestley,[1] "the far greater number of philosophers suppose, and with the greatest probability, that there is a fluid *sui generis* principally concerned in the business of electricity. They seem, however, though perhaps without reason, entirely to overlook Sir Isaac Newton's ether; or if they do not suppose it to be wholly unconcerned, they allow it only a secondary and subordinate part to act in this drama." Among the branches of knowledge that this writer recommends as likely to be of service in the study of electricity is the doctrine of light and colors.

The invention of the Voltaic battery and Sir Humphrey Davy's celebrated experiment in producing the electric arc stimulated inquiry in this same direction. Mrs. Somerville, Morrichini and others sought to produce magnetism by means of sunlight, but ultimately, as is now known, without success.

Notwithstanding these negative results, Faraday had such a "strong persuasion derived from philosophical considerations" of a direct relation between light and electricity, that he resumed the inquiry in a most searching manner, with the happy result of discovering the rotation of the plane of polarization of light by means of magnetism. "Thus is established," he says,[2] "a true, direct relation and dependence between light and the magnetic and electric forces; and thus a great addition [is] made to the facts and considerations which tend to prove that all natural forces are tied together and have one common origin."

It was thus reserved for Faraday to make those discoveries and to obtain that insight into electric and magnetic action which were needed by his great disciple and interpreter Maxwell to construct a most marvelous theory of the connection between these two departments of physical science.

Respecting the failures to obtain magnetism from the direct action of sunlight, to which allusion has been made, Maxwell says that we should not expect a different result because the distinction between magnetic north and south is one of direction merely; that there is nothing in magnetism indicating such opposition of properties as is seen at the positive and negative poles of a battery

[1] Hist. of Elect., Vol. 2, p. 22.
[2] Exp. Researches, 2221.

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in electrolysis; that even right and left handed circularly polarized light cannot be considered the analogue of the two poles of a magnet, for the two polarized rays when combined do not neutralize each other but produce plane polarized light.

It may be said, however, that if a right-handed, circularly polarized ray produces magnetism in one direction and a left-handed ray in the opposite, then the combination of the two rays may neutralize their magnetic effect, inasmuch as plane polarized light may have no magnetic influence. Prof. J. J. Thomson has lately shown mathematically[1] that a circularly polarized ray does have a magnetic effect, but that it is so small, even with strong sunlight, as to be much beyond the limits of experiment; and Mr. Shelford Bidwell[2] has produced a bar of iron in such an exquisitely sensitive magnetic state that magnetic changes are certainly produced in it by the direct action of light. This he has accomplished by rendering the bar more susceptible to magnetic influences in one direction than the other. We may not, I venture to affirm, be without hope that magnetism and electric currents may yet be evoked by the direct agency of sunlight.

Faraday was deeply convinced that space has magnetic properties, and that the space or medium round a magnet is as essential as the magnet itself, being a part of the magnetic system. To him all magnetic and electric action took place by contiguous particles along lines of force. "What that magnetic medium, deprived of all material substance, may be, I can not tell," he says,[3] "perhaps the ether." No doubt existed in Faraday's mind that these lines of force represent a state of tension; but whether that tension is a static state in the ether, or whether it is dynamic, resembling the lines of flow of a current between the poles of a battery immersed in a conducting fluid, was uncertain. He inclined, however, to the latter view. He was thus led to advocate, though not without hesitation, the physical nature of lines of force.

Faraday's discoveries, and his method of regarding all magnetic and electric actions as propagated through a medium by means of contiguous parts, have been of the utmost productiveness. They have revolutionized the science of electricity, and have been the most potent factors in the genesis of a theory, including all ra-

[1] Applications of Dynamics to Physics and Chemistry, p. 78.
[2] London Electrician, March 22, 1889.
[3] Exp. Researches, 3277.

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diant energy, which has recently received such remarkable and conclusive confirmation. His name has become almost a household word. His earnest, unselfish life has added unnumbered millions to the world's wealth. His ideas and words, which have been instruments in the hands of philosophers, have become the current coin of the commercial tyro, who talks as glibly about lines of force and the magnetic circuit as if—he really knew something about them.

Fruitful as Faraday's ideas were they yet awaited a mathematical interpreter for their highest development. A good Providence sent James Clerk Maxwell, whose brilliant mathematical ability was equaled by his philosophic insight, his poetic feeling and imagination, his profound sincerity and his great sympathy with nature. Hear him sing at Aberdeen:—

"Alone on a hillside of heather,
I lay with dark thoughts in my mind,
In the midst of the beautiful weather,
I was deaf, I was dumb, I was blind.
I knew not the glories around me,
I counted the world as it seems,
Till a spirit of melody found me,
And taught me in visions and dreams."

"For the sound of a chorus of voices
Came gathering up from below,
And I heard how all Nature rejoices,
And moves with a musical flow.
Oh! strange! We are lost in delusion,
Our ways and our doings are wrong,
We are drowning in wilful confusion
The notes of that wonderful song."

To appreciate Maxwell's relation to theories of electrical action it is desirable to take a retrospect of the views that have been held regarding its nature. Three periods in the history of these views may readily be distinguished. The first was introduced by Dr. Gilbert in 1600 and it lasted about two hundred twenty-five years. The little that was known previous to Gilbert constitutes only the preface or introduction to the history proper. Nearly three-fourths of this period was utterly barren and unfruitful. It knew nothing better than unctuous effluvia and electric atmospheres. In the latter half of the period the Newtonian philosophy had become the orthodox doctrine. The great success attending the mathematical

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investigations founded upon the law of inverse squares naturally carried with it the acceptance of the underlying hypothesis of "action at a distance." There were not lacking, indeed, men of deeper philosophic insight who denied this doctrine, which they looked upon as entirely unphilosophical and which must utterly bar the way to any inquiry into the process by which the law is executed. Action at a distance by attraction or repulsion, varying inversely as the square of that distance, means an ultimate fact not admitting of further analysis.

The second period was one of contention. It began not with the important discovery of current electricity, nor of the electro-magnet, but with the philosophical methods and concepts of Faraday. The physical postulates of the mathematical school were entirely alien to the views which he adopted. "Faraday, in his mind's eye, saw lines of force traversing all space where the mathematicians saw centers of force attracting at a distance; Faraday saw a medium where they saw nothing but distance; Faraday sought the seat of the phenomena in real actions going on in the medium, they were satisfied that they had found it in a power of action at a distance impressed on the electric fluids."[1] Prior to Faraday the supporters of a medium to explain electric and magnetic action were always thrown out of court for lack of evidence; Faraday gave them a legal standing by furnishing the facts and evidence on which they could well afford to base their case.

The corpuscular theory of light, which had shown such remarkable vitality, was now in the last stages of a fatal disease due to indigestion and lack of assimilation. Foucault finished it off in 1865 with his crucial experiment to decide upon the relative velocity of light in air and water. The undulatory theory was thus fully established, and the doctrine of radiant energy in general began to be clearly apprehended. The grand generalization of the Conservation of Energy was looming up all along the horizon of science, as the towers and spires of a great city appear to rise out of the sea to a traveller approaching the land. Victory was ready to perch on the banners of an army contending for the ether doctrine—not a decimated army but one constantly augmenting in numbers by deserters from the enemy.

At this period, sixteen years ago, appeared the epoch-making book of Maxwell on Electricity and Magnetism. Its author professes

[1] Maxwell's Elec. and Mag., p. x.

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only to translate Faraday's ideas into mathematical language; but he did vastly more than this. He demonstrated mathematically that the properties of the medium required to transmit electromagnetic action are identical with those of the luminiferous ether. It would be unphilosophical, he remarks, to fill all space with a new medium whenever any new phenomenon is to be explained; and since two branches of science had independently suggested a medium requiring the same properties to account for the same phenomena in each, the evidence for the existence of a single medium for both kinds of physical phenomena was thereby greatly strengthened. The step from identity of the medium to identity of phenomena, that is, that light itself is an electromagnetic phenomenon, though it may now seem to be a short one, must nevertheless upon careful consideration always be accepted as evidence of the greatest genius. To walk in Maxwell's footsteps now and take the very steps he took is one thing and a comparatively easy one; but to make original explorations into unknown regions of nature and to tread where no human being has ever before set foot is quite another thing. The electromagnetic theory of light must be regarded as a great generalization inferior only to that greatest one of all time — the Conservation of Energy.

The principal criteria upon which Maxwell relied for the confirmation of his theory may be briefly enumerated:—

1. An electromagnetic wave or undulation is propagated through the ether with a velocity equal to the ratio of the electromagnetic to the electrostatic unit of quantity. If light is an electromagnetic phenomenon its velocity must also be equal to this same ratio. The very close approximation of the one to the other, as determined by a variety of methods, has been known for some time.

2. The specific inductive capacity K of any transparent medium or dielectric should equal the square of its index of refraction. The discrepancies at this point are so great that all one can say in the most favorable case is that K is the most important term in the expression for the refractive index; while in other cases no confirmation whatever can be drawn from this class of evidence.

3. The magnetic and electric disturbances are both at right angles to the direction of propagation of the wave and at right angles to each other. The mathematical form of the disturbance agrees with that which constitutes light in being transverse to the direction of propagation. Further, the *electric* disturbance should

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be perpendicular to the plane of polarization of plane polarized light.

4. In non-conductors the disturbance should consist of electric displacements, but in conductors it should give rise to both electric displacements and electric currents by which the undulations are absorbed by the medium. Most transparent bodies, it is true, are good insulators and all good conductors are opaque. The opacity is, however, far from being proportional to the conductivity.

5. But perhaps the most important criterion of all is the one relating to the very existence itself of a medium. Such a test lies in the *time element* involved in transmission from point to point. Since energy is transmitted from a luminous body as the source to another one which may absorb it, then plainly if time is required for the transmission, the energy must reside in the medium by which the transmission is effected during the interval between the emission and the absorption. In the emission theory the light corpuscles are the receptacles of the energy and carry it with them in their flight. According to the undulatory theory the medium filling all space is the receptacle of the energy and passes it along from point to point by the action of contiguous parts. Foucault's *experimentum crucis* proved the emission theory untenable. Roemer's observation of the retardation of the eclipses of Jupiter's satellites when the earth is moving away from Jupiter, is therefore a confirmation of the undulatory theory of light; and, in consequence, a demonstration of the existence of the luminiferous ether.

At this point the history of the nature of electric action touches upon the third period.

The period upon which we have just entered may not inappropriately be called the period of confirmation. Nothing further appears to be necessary for the complete demonstration and establishment of the electromagnetic theory of light. The noteworthy experiments of Professor Hertz of Carlsruhe are known to all. Rightly conceiving that the reality of electromagnetic waves would be best established by the same experiments which would establish the fundamental identity of such undulations with those of light, he had recourse to the principle of resonance or sympathetic vibrations for the detection of these long-period waves. By a device no less remarkable for its simplicity than its effectiveness he produced electric oscillations of such rapidity that the waves in the surrounding region were short enough to be measured. This he accomplished

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by attaching to the secondary terminals of an induction coil two rectangular sheets of metal, each supplied with a short, stout wire ending in a small ball. The balls were brought near each other and the discharges of the coil took place between them. Under these conditions the discharge is oscillatory, and the period may be calculated by the formula of Sir Wm. Thomson published in 1853.[1]

The receiving apparatus is also of the simplest design, consisting ordinarily of a circle of wire interrupted at a point with an adjustable opening, and of such dimensions that the waves passing through the circle may set up electric oscillations in it synchronizing with those of the transmitting apparatus. The passage of sparks across the narrow opening of the circle indicates an electrical flow; and the necessity of adjusting the size of the circle in order to obtain this flow proves that the forces acting are periodic. The receiving apparatus must in fact be tuned so that the period of an electrical oscillation in it shall correspond with the external impulses absorbed. The intensity of the electric and magnetic disturbances is indicated by the relative length of sparks obtainable.

Equipped with this apparatus, which was installed in a large lecture hall, Hertz found not only that his tuned receiver responded to the impulses of the transmitter in the precise manner pointed out by theory, but that the sparks showed a series of maximum and minimum values recurring in periodic order as the receiver was carried further away from the source of the disturbance. The astounding fact was thus brought out that these electromagnetic waves were reflected from the thick wall of the room, and that the combination of the direct and reflected systems produced stationary waves with loops and nodes that could be traced out by the responsive circle of wire. In this manner wave-lengths were measured down to 60 cms., and the time element was experimentally detected in the propagation of electrostatic and electrodynamic induction. It was demonstrated that the disturbances producing the waves are at right angles to the direction of propagation, as Maxwell predicted and as interference phenomena show them to be in light. Hertz has also found an electrodynamic shadow cast by an iron post; he has verified the laws of reflection from plane and concave reflectors, and has shown that electric waves suffer refraction and polarization in a manner exactly analogous to light. Professor Fitzgerald of Dublin has added another confirmation of Maxwell's doctrine, demon-

[1] Math. and Phys. Papers, Vol. 1, p. 540.

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strating that the *electric* disturbance is perpendicular to the plane of polarization, as Maxwell's equations require. Finally, the velocity of propagation of these electrodynamic waves is found to be the same as the velocity of light. Thus not only have all of Maxwell's criteria except the second abundantly confirmed the judgment of the great physicist, but other proofs have been added.

Electromagnetic waves are therefore not only like light but they are light. Or, perhaps to speak more exactly, all radiant energy is transmitted as electromagnetic waves in the luminiferous ether. Electricity has thus annexed the entire domain of light and radiant heat; and, as Professor Lodge says, has become a truly imperial realm. The difference of wave-length in the three classes of phenomena is not a fundamental one. Increase the rate of the electrical oscillations a million fold in Hertz's experiments and the waves would not merely resemble light—they would be light. A wire through which such oscillations are surging back and forth would glow with light. Even the long heat waves would be absent and only those producing the sensation of light and color would remain.

It will be observed that the oscillations of an electric discharge constitute the point of departure for the admirable researches of Hertz; and it is a matter in which we may modestly take a bit of national pride that the first case of electric oscillations was discovered by an American physicist. The oscillatory character of the Leyden jar discharge was demonstrated by Joseph Henry in 1832 by means of the magnetic effects produced in small steel needles. It was not till twenty-one years later that Sir Wm. Thomson published the complete mathematical theory of such oscillations. They have since been observed directly by means of a rotating mirror. Dr. Oliver Lodge has recently shown that they rotate the plane of polarization of light in one direction and then the other as they surge back and forth. He has also reduced the number of oscillations from several millions to a few hundred per second by increasing the capacity and the self-induction. The discharge then vibrates within the limits of audibility and produces a musical note.

The well-known experiment of Henry, in which he observed an induction current in a wire stretched parallel to and distant thirty feet from one which served to discharge a Leyden jar, is now known to have been a case of resonance, that is, the absorption of electric waves by a conductor producing currents therein. And it is an evidence of the great genius of Henry that he saw, somewhat dimly it may be, but still with a certain degree of rational apprehension,

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that the induction was transmitted across the intervening space with a velocity comparable only to that of light. He had perchance the divine touch of genius necessary for the great discovery of electromagnetic waves coursing through the ether; but the way leading to this important physical fact had not then been sufficiently prepared and its discovery was impossible.

Waves similar to those of a Leyden jar discharge but of longer period are sent out from a wire conveying alternating currents. We must conceive of such a wire not simply as affected internally or even superficially by the electric energy surging through it, but as the source from which pulsate outward through the limitless ether great waves of electrodynamic disturbance. For three hundred complete alternations per second, these waves are a million meters, or over six hundred miles, in length. They present a marked contrast to the waves corresponding to the D lines of the spectrum which are only about one five-millionth of a millimeter long.

These long waves from an alternating current represent energy. Through space it is conveyed with the velocity of light, and through other non-conductors or dielectrics with a smaller velocity, precisely as in the case of the radiant energy of light or heat. Henceforth the complete equation for the distribution of energy by means of alternating currents must include a term to express the radiation from the circuit. It may indeed be found that this term represents no inconsiderable part of the energy communicated to the wire in the case of very rapid alternations.

Thus we see that the ether plays a magnificent *rôle* in what may be called its dynamic relation to electric displacements. In its capacity, as a reservoir of static or potential energy, its agency has been better understood for a considerable period. When a continuous current begins to flow through a closed circuit a single wave travels out from the conductor; and during its progress, while the current is approaching its constant value, the enclosing ether is assuming its condition of static repose under stress. The whole ether, extending indefinitely outward from the conductor, is profoundly modified. We know how to map out the circular lines of force about it by means of iron filings; but the iron serves only to show what has already taken place in the ether before the filings are brought into the field. Every little iron particle becomes a magnet with all the north-seeking poles stretching in one direction round the wire, and all the south-seeking poles in the other. What the mechanism of the stress, or the motion in the ether to produce these effects may

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be, we do not know; but we do know that these lines of force are all subject to a tension tending to shorten them, and that they are mutually repellent laterally. When a current is sent through a conductor the ether is expanded in concentric cylindrical layers about any straight portions of the circuit, and becomes the reservoir of potential energy. As soon as the current which maintains this state of tension ceases to flow the stretched ether collapses upon the conductor, yielding up its energy in the form of self-induction. If a steady current is conceived as the setting up and breaking down of a static difference of potential at infinitesimal intervals of time, then the energy transmitted may depend upon a similar formation and decay of the static stress in the encompassing ether. The conductor is but the core of an electromagnetic disturbance in the surrounding medium; and it may be that the enormous energy which a small copper wire can apparently convey is in reality transmitted by the invisible medium.

From this brief review of the theory of electric action it will be quite evident that henceforth the language applied to electrical phenomena must always include as a prominent term the luminiferous ether. The experiments of Hertz have made it impossible to explain electrical facts without taking this invisible medium into account. There is no such thing as electric or magnetic action at a distance. The ether is always an essential part of that complex system the interactions of which manifest themselves as electric or magnetic phenomena.

As the ear responds to the slow oscillations of an electric discharge through the intermediate agency of heat, so the eye of the mind responds to those more rapid oscillations the existence of which has been demonstrated by experiment. No less clearly does the magnetic field appear as a system of lines of stress in the ambient ether. Definiteness has taken the place of the metaphysical speculations of earlier times. Complete ignorance has at least been superseded by half knowledge. We may not yet affirm with Edlund that the ether *is* electricity, but we are doubtless nearer a solution of this old problem than ever before.

"The discord is vanishing slowly,
And melts in the dominant tone.
And they that have heard it can never
Return to confusion again,
Their voices are music forever,
And join in the mystical strain."

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PAPERS READ.

On the partition of the mean kinetic energy of a perfect gas between the rotary and translatory motions of its molecules. By Prof. H. T. Eddy, Cincinnati, Ohio.

[ABSTRACT.]

Considering a molecule to be a free body, which has motions of rotation and translation with respect to each of its three principal axes of inertia, let us fix our attention upon the motion with respect to one only of these axes and call it, for convenience, x.

The actual motion at any instant with reference to x is on a screw of some determinate pitch of which x is the axis. In the paper before us this actual screw motion is resolved into two screw motions both about x, and of such pitch that they perfectly replace the single screw motion both kinematically and kinetically. It is shown that this condition holds when the original screw motion is replaced by a motion compounded of motions upon two screws, one right-banded and the other left-banded, of which the pitch of both is, under all circumstances, constant and equal to the radius gyration of the molecule about x.

It further appears that since during the fortuitous molecular encounters which control the rotary and translatory motions, the rotary impulses about x are independent of the translatory impulses along x, there is no more probability that a positive rotary impulse will be associated with a positive translatory impulse than with a negative translatory impulse. Hence, motions on each of the component screws are independent and equally probable.

But in each of the component screw motions into which the actual motion has been resolved, the total energy is half of it rotary and half of it translatory. Hence the total kinetic energy of the molecule is half rotary and half translatory.

Note on the magnetic rotation of polarized light according to the electro-magnetic theory. By Prof. H. T. Eddy, Cincinnati, Ohio.

[ABSTRACT.]

Partial differential equations, expressing the propagation of plane polarized light in a magnetic field, have been published by Professor Row-

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land in the Am. Jour. Math., Vol. III, p. 109, into which he has introduced terms expressing the transverse electromotive force due to the Hall effect.

The particular solution of these equations which he proposes contains a periodic factor dependent upon the time.

In this note a different, particular solution, containing a periodic factor dependent upon the space which the ray traverses in the field, is discussed at length and compared with the solution proposed by Professor Rowland.

It is shown that the amount of the magnetic rotation would be the same whichever form of solution we adopt, but that the velocity of the ray would be increased if there is a periodic factor dependent upon the time alone, but the velocity would be decreased by a periodic factor dependent upon the space.

The physical ideas connected with this manner of propagation of light are such as to lead us to regard a decrease of the velocity by the transverse electromotive force arising from the Hall effect as extremely probable.

Preliminary experimental investigations, made conjointly by Prof. Thos. French, jr., and the author, have as yet led to no decisive result.

In the last part of this note the author has examined the more general solution of these differential equations containing a periodic factor dependent upon both time and space.

AN APPARATUS FOR THE EXPERIMENTAL SOLUTION OF THE PROBLEM STATED IN PROFESSOR EDDY'S PAPER ON THE MAGNETIC ROTATION OF POLARIZED LIGHT. By Prof. EDWARD W. MORLEY, Cleveland, O.

[ABSTRACT.]

IT is required to determine whether the velocity of light in carbon bisulphide is affected by a magnetic field. The apparatus is intended to apply the method of interferences to the measuring of the difference of velocity in question, and also at the same time to the determining the constancy of position of certain parts of the optical apparatus used, so as to detect an effect even if it be very small.

RELATIVE MERITS OF DYNAMOMETRIC AND THE MAGNETIC METHODS OF OBTAINING ABSOLUTE MEASUREMENT OF ELECTRIC CURRENTS. By Prof. THOMAS GRAY, Terre Haute, Ind.

[ABSTRACT.]

THIS paper consists of a discussion of the methods commonly adopted for the measurement of electric currents by the electrodynamic and the

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magnetic methods. The methods of determining the value of the horizontal intensity of the terrestrial magnetic field and of using it in the current measurement are examined and some modifications in the detail of the method are suggested both in the ordinary Gauss and in the suspended coil Kohlrausch method. The measurement of the dimension of standard galvanometer coils is also examined in connection with this method and a means of obtaining high accuracy described.

The degree of accuracy attainable from the instrumental point of view is found to be within one-twentieth per cent of absolute.

In the dynamometric method a general agreement is expressed with the position taken up by Lord Rayleigh and the opinion given that this method could be made to give an accuracy within one-hundredth per cent of absolute.

As to secondary standards, the magneto-static galvanometer, the electro-chemical equivalents of silver and copper and the standard balance as designed by Thomson, are each considered and a preference expressed for the balance, with occasional redetermination of the constant by electrolysis, as the most convenient and reliable instrument for ordinary use.

EXPERIMENTS FOR DEMONSTRATING THAT THE FORCE OF A DETONATING EXPLOSIVE IS EXERTED IN ALL DIRECTIONS ABOUT THE EXPLOSIVE CENTRE. By Prof. CHARLES E. MUNROE, U. S. Torpedo Station, Newport, R. I.

[ABSTRACT.]

THERE is a popular belief that the force of exploding gunpowder is exerted upwards, while that of the detonating high explosives is exerted downwards, and that this belief is shared by some men of science is shown by a statement of L. Gattermann in Ber. d. chem. Ges., XXI, 751–757, 1888, that it is a characteristic of nitrogen chloride that the explosion takes place in a downward condition.

In the experiments described, equal and similar masses of gun-cotton are placed on an iron plate suspended horizontally in mid-air. One mass of gun-cotton is placed on the upper surface of the plate, in the centre of one-half, while the other mass of gun-cotton is placed on the under surface and in the centre of the other half of the plate. The detonators in the gun-cotton blocks are connected in series and fired simultaneously and from inspection of the effects produced, it is impossible to tell which was the upper and which the lower surface of the plate.

Again, a detonator, containing thirty-five grains of mercury fulminate, is fired in a closed cylindrical vessel of iron filled with water, when by the action of the detonator the vessel is forced into a nearly spherical shape.

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A QUADRANT ELECTROMETER. By Prof. HARRIS J. RYAN, Ithaca, N. Y.

[ABSTRACT.]

THE electrometer needle and quadrants are made of the cylindrical form. To the needle is attached a magnetized steel mirror.

The needle is hung by a single silk fibre and metallic contact is made to the same by means of a very fine platinum wire.

About the quadrants and needle, with its plane in the magnetic meridian and the steel mirror at its centre, is arranged a coil of wire, as in a tangent galvanometer.

The electrometer needle is deflected and then brought back to its "zero" position by balancing with a current in the coil surrounding the same, whereby the magnetized mirror is acted upon by a couple opposite of sign to that acting on the needle. The current is then a measure of the difference of potential to which the electrometer has been subjected, in accordance with the manner in which it may have been arranged.

A SOLAR CONDITION UPON WHICH THE AURORA DEPENDS. By Dr. M. A. VEEDER, Lyons, N. Y.

[ABSTRACT.]

IN this paper a comparison is made between the record of auroras reported from signal service stations in the United States and that of the daily condition of the sun made by the writer for three years from April, 1886 to April, 1889. In general, it is found that the aurora is rarely seen at a single station for two nights in succession, but is usually reported from different stations for about four days at each manifestation. Recurrence at intervals corresponding very closely to the time of the rotation of the sun is common. During 1888, eighteen such instances were noted, in which the beginnings of the attendant magnetic perturbations, as shown by the tracings from the declination magnetograph at the Naval Observatory, Washington, were so abrupt, that it might be possible by this means to determine the time of the revolution of the sun, the average period thus found being twenty-six days and eight hours. In 1886 also, there were seven returns at like intervals, forming a single series of the finest auroras during the entire three years. A comparison of the tracings of the magnetograph shows that the average duration of each outbreak is not far from four days.

This behavior of auroras and magnetic storms indicates that any solar disturbance which may originate them has this power during a limited portion only of its transit across the earthward side of the sun. Although such disturbance may remain active throughout successive returns, the earth remains within range of its impulse during only about four days at each transit. During the three years in question, there were one hun-

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dred and eighty-eight characteristic outbreaks of the aurora, as above described; for twenty-six of these, observations are lacking. In connection with the remaining one hundred and sixty-two, in every instance more or less bright faculæ with or without dark spots was upon the sun's eastern limb appearing by rotation. In a very large proportion of cases these solar disturbances were so evidently active and isolated upon the sun's disc that the conclusion is very strongly justified that spots and faculæ in this particular location have the power of originating auroras. On the other hand, in very numerous instances, extensive outbreaks elsewhere were not attended by the aurora. In only twenty-two instances were spots and faculæ appearing by rotation not attended by the aurora within the United States. The majority of these cases were in June and July and the aurora was probably visible in higher latitudes, there having been decided magnetic perturbations, so far as tracings from the magnetograph are at hand.

It is noteworthy that an increase in the number of stations reporting thunderstorms, as a rule, follows the appearance by rotation of solar disturbances, although a very bright aurora may be attended by some temporary decrease for a day or so, as though it had taken their place. The curve, denoting the number of stations reporting winds above fifteen miles at seven A. M. each day, also rises as a rule whenever a solar disturbance is appearing by rotation, but this curve corresponds more closely to that of thunderstorms than that of auroras.

Essentially, this paper is a bare synopsis of the results of daily observations and is intended as a report of progress. No attempt is made to account for the grouping of phenomena revealed, although it is evident that the subject has an important bearing upon many questions in physics.

A PRELIMINARY REPORT ON THE INFLUENCE OF TEMPERATURE UPON THE COLOR OF PIGMENTS. By Prof. EDWARD L. NICHOLS AND BENJAMIN W. SNOW, Cornell University, Ithaca, N. Y.

[ABSTRACT.]

IN this investigation a variety of substances, most of which were metallic oxides, were illuminated by an incandescent lamp, held at constant candle-power. The light reflected by them at the temperature of the room, and at various high temperatures, was then subjected to a spectrophotometric analysis. For this purpose each substance in the form of a uniform film of dry powder, was placed upon the surface of a strip of platinum foil. The foil was heated to the point at which measurements were to be made, by means of the current from a storage battery; its temperature being determined from the linear expansion.

The general law commonly supposed to hold, that the change of color in pigments, with rise of temperature, is always "towards the red," was not substantiated. It was found, however, without exception, that the substances experimented with suffered decrease of reflecting power when

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heated; and that all wave-lengths of the visible spectrum were subjected to greater absorption by the hot than by the cold pigment. In some cases this increased absorption occurred in nearly like proportion throughout the spectrum; in other cases it was selective.

The authors hope in the near future to extend their measurements to a much larger number of substances, including many organic compounds.

AN IMPROVED CLARK STANDARD CELL WITH LOW TEMPERATURE COEFFICIENT. By Prof. H. S. CARHART, Ann Arbor, Mich.

[ABSTRACT.]

THE paper describes first the improvements desirable in a standard cell. Some directions are then given respecting the preparation of materials for such a standard.

Some account of the local action going on in the old type of Clark cell in which zinc replaces mercury in the mercury salt. The temperature coefficient of these new cells is represented by the equation

$$E.\ M.\ F. = E\,[1 - 0.000387\ (t - 15) + 0.0000005\ (t - 15)^2].$$

It will be seen that the coefficient diminishes slightly as the temperature rises, while in Lord Rayleigh's cells it increases with rise of temperature.

Method of comparing E. M. F.'s described.

The E. M. F. of a cell prepared by my method is three or four-tenths per cent higher than the Lord Rayleigh form.

The polarization in these cells amounts to one ten-thousandth part in five minutes when closed on an external circuit of 10,000 ohms.

[Printed in full in the AMERICAN JOURNAL of SCIENCE, November, 1889.]

MAGNETIC LEAKAGE IN DYNAMOS. By Prof. H. S. CARHART, Ann Arbor, Mich.

[Printed in full in the WESTERN ELECTRICIAN (Chicago), Aug. 31, 1889; and in the London ELECTRICAL REVIEW, Sept. 15, 1889.]

CONCERNING THERMOMETERS. By Prof. WM. A. ROGERS, Waterville, Me., and Prof. R. S. WOODWARD, Washington, D. C.

[ABSTRACT.]

(*Part I by Wm. A. Rogers.*)

(1) The movement of a mercurial column is by pulsations.

(2) These pulsations have a regular recurrence.

(3) The range of pulsations is constant in the same thermometer and varies between 0.25° and 1.1° in the different thermometers investigated.

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(4) Every pulsation has the same harmonic relation, whatever the part of the scale at which the reading occurs.

(5) The amplitude of the curve which represents this harmonic is a constant and varies between 0.18° and 0.53° for the thermometers investigated.

(6) Since the range of pulsations is constant and the time required for the completion of the cycle is variable, it follows that the danger of error in random readings of the thermometer is greater for slow than for rapid variations of temperature.

(7) Method of reading thermometers by which the errors in question are eliminated.

(8) A part of the errors in question are undoubtedly due to the personality of the observer in estimating the fractional subdivisions of the scale but the errors still remaining are periodic in their character. In any event, the mean of the readings taken at equal intervals of time throughout a complete cycle of changes, will be substantially free from errors of the class pointed out in this paper.

(*Part II by R. S. Woodward.*)

The object of this paper is to give a theoretical explanation of the periodic or pulsating movement of a mercurial thermometer column discovered and described by Prof. W. A. Rogers. The theory applies to all thermometers of the mercurial thermometer type, and it may be called the dynamical theory of such thermometers.

It is assumed that the column of the thermometer is subject to the action of the following forces: (1) the elasticity of the bulb generated by the expansion of the liquid of the thermometer; (2) the mass or inertia of the column; and (3) the frictional and other resistances, including whatever effect may arise from surface tension at the end of the column.

Let

v_0 = volume of liquid in bulb at time $t = 0$,
v = volume of liquid in bulb at time $t = t$,
m_0 = mass of liquid in column at time $t = 0$,
s_0 = length of column at time $t = 0$,
Δs = rise of column in time t,
ω = cross-section of column,
ε = coefficient of expansion of the liquid,
τ = temperature of liquid in bulb at time t,
ρ = density of liquid in column at time t,
r = rate of temperature rise = $\frac{d\tau}{dt}$,
F = frictional and other resistances.

It is evident that

$$v = v_0 + v_0\varepsilon\int_0^t r dt - \omega\,\Delta s;$$

and if p be a suitable factor, the increment of pressure generated by the expansion of volume v in the instant dt will be

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$$pv\varepsilon r dt = p\varepsilon \left(v_0 + v_0 \varepsilon \int_0^t r dt - \omega \Delta s\right) r dt.$$

The mass in the column at the time t is

$$m_0 + \omega \Delta s \rho = m_0 \left(1 + \frac{\Delta s}{s_0}\right).$$

Hence by d'Alembert's principle

$$m_0 \left(1 + \frac{\Delta s}{s_0}\right) \frac{d^2 \Delta s}{dt^2} = \left(p\varepsilon v_0 + p\varepsilon^2 v_0 \int_0^t r dt - p\varepsilon \omega \Delta s\right) r - F. \qquad (1)$$

This is the general equation of motion. Its use requires a knowledge of r and F. The only case here considered is that in which r and F are constant. In this case, if we neglect the fraction $\frac{\Delta s}{s_0}$, which may be done for a single or a few pulsations, equation (1) gives the following integral:

$$\Delta s = a \sin(t\sqrt{\beta} + \theta) + \frac{\alpha}{\beta} t + \frac{\gamma}{\beta}, \qquad (2)$$

in which a and θ are the constants of integration, and

$$\alpha = \frac{p v_0 \varepsilon^2 r^2}{m_0},$$

$$\beta = \frac{p \varepsilon r \omega}{m_0}, \qquad (3)$$

$$\gamma = \frac{p \varepsilon r v_0 - F}{m_0}.$$

Certain experimental results following the law of equation (2) were cited and explained.

ON GLOBULAR LIGHTNING. By Prof. T. C. MENDENHALL, Superintendent U. S. Coast and Geodetic Survey, Washington, D. C.

[ABSTRACT.]

THE paper reviews briefly the evidence for the existence of globular lightning as presented by Arago and others with additional information and quotations drawn from earlier literature. Testimony of recent observers is then related and the conclusion is reached that in view of the mass of evidence, and notwithstanding the conflicting character of much of it, the reality of the phenomenon must be admitted.

THE MEASUREMENT OF MAGNIFICATION IN THE MICROSCOPE. By Prof. W. LECONTE STEVENS, Brooklyn, N. Y.

[ABSTRACT.]

THIS paper is a criticism of the rule commonly employed for estimating magnification in the microscope, that of dividing 100 by the product of the nominal focal lengths of objective and eyepiece. The deduction of this

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rule is given, and its roughly approximate character is shown in the assumptions it involves.

A method is given and a formula deduced for determining the focal length of the eyepiece and the same is done for the determination of the focal length of an objective without implying any knowledge of the position of its optical centre. Illustrations are given of the application of these methods.

Two independent methods are given for determining the magnifying power of a combination consisting of objective and eyepiece, and the results of the two are compared.

These results are further compared with that obtained by applying the common formula,

$$M = \frac{100}{ff'}$$

and it is shown that under the conditions assumed for its application much more accurate labelling is needed than that usually applied by the makers of these instruments.

RESEARCHES ON SONOROUS SAND IN THE PENINSULA OF SINAI. By Dr. H. CARRINGTON BOLTON, New York, N. Y.

[ABSTRACT.]

THIS paper is in continuation of two others on Musical Sand presented jointly with Dr. Alexis A. Julien at the meetings in Minneapolis and Philadelphia. After alluding to a recent lecture by Mr. Cecil Carus Wilson of England on the singing beach at Bournemouth, the speaker proceeded to narrate his own researches in Arabia Petræa. Leaving New York, January 2, 1889, I reached Cairo January 31st, and in March entered the desert of Sinai; the village of Tor which is the starting point for *Jebel Nagous* is on the Gulf of Suez, but cannot conveniently be visited by water owing to contrary winds. Jebel Nagous is off the regular caravan routes and is not popularly known, hence has been visited but nine or ten times in eighty years by scientific travellers. About four and one-half hours northwest of Tor is the long detached mountain known as Jebel Nagous (or Abu Suweirah). On the steep slopes of this mountain rest several large banks of sand; one of these, which I distinguish by the name Seetzen's Bell Slope, after its discoverer, emits distinct musical sounds whenever the sand slides down the incline either spontaneously or through the agency of man. The mountain consists of massive white sandstone carrying quartz pebbles and veins; it is about three miles long and 1,200 feet high. The huge Bell Slope measures 260 feet across the base, five or six feet across the top and is 390 feet high; it is bounded by nearly vertical walls of sandstone. The yellowish white sand rests on the rocks at the high angle of 31°, is very fine grained, and composed chiefly of quartz and calcareous

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sandstone. The grains are well rounded to subangular, and silt is notably absent. As the sand reposes at a high angle it possesses a curious mobility which causes it to flow down the incline like soft pitch or molasses; the sand above the point of disturbance falls into the depression and this depression advances up the slope at the same time. This downward flow takes place spontaneously whenever the sand, forced up the incline by the violent winds, accumulates in such quantity as to exceed the angle of rest. The movement is accompanied by a strong vibration and by a musical tone resembling the lowest bass note of an organ with a tremolo stop. The larger the bulk of sand moved the louder the sound; it is by no means so sensitive as the sand of so-called singing beaches (which I have described elsewhere), and fails to emit sounds when struck with the hand or clapped together in a bag. The vertical cliffs on either side yield an echo that may magnify and prolong the sounds, which were loud enough to be heard several hundred feet. The peak of Jebel Nagous rises above the Slope to the height of 955 feet above the sea level.

The sand of the Slope is derived partly from disintegration of the rock itself and partly from the more distant plain below, from which violent winds blow it up on to the mountain side.

The Bedouins of the region account for the acoustic phenomenon by attributing it to the *Nagous* or wooden gong of a subterranean monastery in the heart of the mountain, and claim the sounds can only be heard at the hours of prayers.

Several other sandbanks presenting a similar appearance to the eye were tested but gave out no musical sounds whatever. Microscopical examination of these sands shows that they contain much silt, which prevents the vibrations necessary to yield the sounds. After careful study, however, of Seetzen's Bell Slope I became convinced that the phenomena could not be unique in the desert as supposed, and I made systematic search for another locality. After testing many sandbanks on the journey northward to Suez I discovered, April 6th, banks of sonorous sand resting on low cliffs a quarter of a mile long. This new locality is in Wadi Werdân about a day and a half from Suez, by camels, and is on hillocks called Ojrat Ramadân.

The sand blown from the extensive plains to the north, falls over the southern face and rests at two angles, 31° at the top and 21° or less near the base. Wherever it possesses the mobility before described it emits a distinct musical note on being disturbed. The highest bank measures only sixty feet on the incline, and it is not probable that the sounds can occur spontaneously. Dr. Julien has named the new locality Bolton's Bell Slope, and reports that microscopical examination shows the sand to consist chiefly of quartz grains, and a larger proportion of calcareous sandstone than at Jebel Nagous. The size of the grains of quartz varies from 0.11 to 0.42 mm. and of sandstone 0.11 to 0.34 mm., the average being smaller than that of the sand grains on Jebel Nagous. Like the latter it is very free from silt.

Various hypotheses have been proposed to explain the cause of the sonorous property in certain sands. Sir James Prinsep, Secretary of the

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Asiatic Society of Calcutta, attributes the sound produced at Jebel Nagous to a "reduplication of impulses setting air in vibration in a focus of echo." Hugh Miller, after his visit to the singing beach at Eigg, interested his friend Sir David Brewster in the problem, and he wrote of "accumulated vibrations of the air when struck by the driven sand, or the accumulated sounds occasioned by the mutual impact of the particles against each other." The sonorousness of the sand at Kauai has been attributed to the cellular character of the coralline material, that of Jebel Nagous to its essentially quartzose nature; that of the Baltic coast of Prussia to the saline crust on the beach (Dr. Berendt); but the researches of Dr. Julien and myself show that the sonorous property is independent of material and of saline waters. Many other explanations have been offered which we can here but briefly name: electricity; effervescence of air between moistened grains; solarization; and reverberation within subterranean cavities. Charles Didier, when travelling in Arabia, heard of the acoustic phenomena at Jebel Nagous, and although he did not visit the place promptly offers to explain it by attributing the sounds to "interior cataracts or a subterranean volcano."

Mr. Carus-Wilson, whose paper we have already noticed, explains the sonorousness of sand on a beach as follows: "The music from sand is simply the result of the rubbing together of the surfaces of millions of perfectly clean grains of quartz free from angularities, roughness or adherent matter in the form of clinging fragments investing the grains, and that these microlithic emissions of sound though individually inaudible, might in combination produce a note sufficiently powerful to be sensible to us." (Lecture of Nov. 2, 1888.)

Without attempting to analyze or criticise the above theories, we forthwith give our own, already read to the New York Academy of Sciences on Oct. 15, 1888.

Dr. Julien and I believe the true cause of sonorousness in the sands of singing beaches and of deserts to be connected with thin pellicles or films of air, or of gases thence derived, deposited and condensed upon the surface of the sand grains during gradual evaporation after wetting by the seas, lakes, or by rains. By virtue of these films the sand grains become separated by elastic cushions of condensed gases, capable of considerable vibration, and whose thickness we have approximately determined. The extent of the vibration and the volume and pitch of the sound thereby produced, after any quick disturbance of the sand we also find to be largely dependent upon the forms, structures and surfaces of the sand grains, and especially upon their purity or freedom from fine silt or dust.

Though the environment of the sand on beaches and in the desert differs greatly as respects moisture, we believe that the above theory is applicable to both. Statistics of rainfall in the desert are wanting, but the experiences of travellers and my own observations show that rain falls, in the winter months, abundantly in many parts of the peninsula. In the vicinity of Mount Sinai heavy snows and rain are precipitated in December and January, occasionally causing veritable floods in narrow valleys as

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experienced by Captain Palmer. I noted a two hours' shower in Wadi Feiran in March (1889), and I saw raindrop impressions on mudflakes at several points on the coast. Water, therefore, is not wholly lacking to aid in the chemical cleansing of the sand grains, and the powerful winds accomplish the work of sorting and winnowing done by the waves elsewhere. The fineness of the grains at the Bell Slopes makes the displacement of a very large amount of sand necessary for the production of sound, while the coarser particles on the beaches yield a resonance on a smaller provocation.

We have, elsewhere (Proceedings Am. Assoc. Adv. Science, 1883 and 1884) shown that the pitch of the musical notes produced on sea beaches is directly proportional to the mass of sand moved, the greater the mass the lower the tones; on the Bell Slopes in the desert the large mass moved yields a very deep note. [The paper was illustrated by projections of original photographs.]

DETERMINATION OF THE PULSATION PERIOD OF A JENA-GLASS THERMOMETER. By Prof. WM. A. ROGERS, Waterville, Me., and J. BURKITT WEBB, Hoboken, N. J.

EXPERIMENTAL PROOF OF NEWTON'S LAW OF COOLING. By Prof. WM. A. ROGERS, Waterville, Me.

ADDITIONAL EXPERIMENTAL PROOF OF THE CONSTANCY OF THE RELATIVE COEFFICIENT OF EXPANSION BETWEEN JESSOP'S STEEL AND BRONZE BETWEEN THE LIMITS OF $-5°$ AND $+95°$ FAHR. By Prof. WM. A. ROGERS, Waterville, Me.

THE DETERMINATION OF THE AMOUNT OF RAINFALL. By Prof. CLEVELAND ABBE, U. S. Signal office, Washington, D. C.

EXHIBITION OF A NEW SPECTROSCOPE SLIT. By Dr. ROMYN HITCHCOCK, Washington, D.C.

EXHIBITION OF A THERMOMETER WITH CONSTANT ZERO POINT. By Dr. ROMYN HITCHCOCK, Washington, D. C.

THE HYDRO-ELECTRIC EFFECT OF STRETCHING METALS. By CARL BARUS, U. S. Geological Survey, Washington, D.C.

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EFFECTS OF ELECTROSTATIC DISCHARGES ON PHOTOGRAPHIC PLATES. By Prof. THOMAS FRENCH, JR., University of Cincinnati, O.

A MODE OF SUSPENSION FOR FOUCAULT'S PENDULUM. By Prof. R. B. FULTON, University of Mississippi.

AN EXHIBITION OF PHOTOGRAPHS OF THE FUNDUS OF THE EYE OF THE CAT TAKEN WHILE UNDER THE INFLUENCE OF CHLOROFORM. By A. M. ROSEBRUGH, M.D., Toronto, Ont.

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A MODIFICATION OF THE PASCAL'S VASE EXPERIMENT. By ALBERT L. AREY, Principal of the Free Academy of Rochester, N. Y.

A MOUNTAIN STUDY OF THE SPECTRUM OF AQUEOUS VAPOR. By Dr. CHAS. S. COOK, Evanston, Ill.

RECENT PROGRESS IN STORAGE BATTERIES. By Prof. GEORGE F. BARKER, Philadelphia, Pa.

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ADDRESS

BY

PROFESSOR WILLIAM L. DUDLEY,

VICE-PRESIDENT, SECTION C.

THE NATURE OF AMALGAMS.

THE subject which I have chosen for my address to you to-day is one which may seem pretentious, considering the state of our knowledge of amalgams. Its announcement may lead you to believe that in discussing it here I propose to settle the questions concerning their constitution and chemistry generally, or at least to present to you some new and startling facts which will do much in that direction. At the outset I desire to relieve you of all such expectations. Our knowledge of the subject is entirely too meager and too scattered to even hope for great advances in a short time, and little more than vague speculation can be indulged in, until careful and systematic study has been given to the individual amalgams.

The work has, thus far, been desultory in the extreme; and though many investigators have begun apparently with much zeal, yet their investigations have been cut short with very little progress reported. Little attempt has been made to continue the lines which have been begun by others, but a few bald and superficial facts have been gathered and thrown recklessly into the storehouse where disorder has complete possession. Why this state of things exists I am sure I cannot say, unless it be that most of our workers fly to fields that will yield the quickest returns; and, as organic chemistry holds out such resistless charms and promises so much numerical wealth for the compound builder upon a small capital, those which will produce a slower growing crop, requiring more labor are passed by and almost wholly neglected.

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I have chosen this subject for my address to-day, hoping that as I briefly give the results of some of the most important work that has been done in this rich and unexplored field, some of you may be led into it to reap reward by the discovery of much treasure which is surely there. The beauties do not appear at first on the surface, and it is only after considerable thought and study that the many possibilities and bearings of the work unfold. At first sight it may seem that the labor would consist simply in ascertaining which metals combine with mercury to form amalgams, in determining the composition of the products, and finally in deciding whether or not they are definite chemical compounds. But this is not all. The physical phenomena of their formation are to be investigated as well as their physical and chemical properties; and when this is done and the analogies are drawn and the general laws of their combination formulated, the work is still incomplete, being only introductory to the study of the nature of metallic alloys generally. It will have a most important bearing upon molecular chemistry and physics. It will throw much light on the relative affinities of the atoms and molecules of the metallic elements. Our knowledge of the valence of the metals is derived mostly by comparison through the non-metallic elements. From the formulas of corresponding compounds of the metals with the non-metallic elements we get the comparative affinities of the atoms of the metallic elements, while a careful study of the compounds of mercury with the metals would give a direct comparative value. Who would be led to suppose from the formulas $HgCl_2$ and $AuCl_3$, which show the comparative affinities of mercury and gold for chlorine, that the compound of mercury and gold should indicate the comparative affinity which is represented by the formula Au_8Hg? And so I might enumerate probabilities and possibilities without end, but what has been said will indicate to a slight extent some of the rewards for which we have apparently good reason to hope. They will be attained, however, only by long, patient and careful labor, and after an expenditure of a wealth of ingenuity. He who looks for speedy returns should not enter upon this work for he will meet with discouragement at the very beginning.

The early history of amalgams is exceedingly obscure. The philosopher who first observed and recorded the property which mercury possesses of combining with the other metals is unknown; however, we may conclude that the phenomenon of amalgamation

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did not long remain unrecognized after mercury was isolated and came into use, especially as history serves to show that the metals with which it most readily amalgamates were known to the ancients before the discovery of mercury. It appears that gold, silver, copper, tin, lead and iron preceded it chronologically, as neither Moses nor the older Greek writers make any mention of it. Theophrastus[1] (300 B.C.) seems to be the first to mention mercury, and in his work on minerals he gives a method of preparing it from cinnabar; and he calls it "liquid silver."

The first references to the power of mercury to combine with metals are found in much later works. Pliny in the middle of the first century says that "all things float in it except gold and that alone combines with it." Dioscorides in about 100 A.D. in speaking of keeping mercury says "It can only be contained in glass, lead, tin, or silver vessels, as it corrodes and causes other metals to flow away." Isodorus Hispaliensis (about 700) makes similar reference. Juncker[2] (1730) considers that mercury which has been artificially prepared has greater affinity for the metals than the native mercury.

The gold amalgam was the one best known to the ancients and they soon saw the value of mercury for the extraction and purification of that metal. Pliny says the best way to purify gold is to form an amalgam and squeeze out the excess of mercury through skins. He says it flows through "like sweat through the body and leaves pure gold."

Vitruvius gives similar directions for recovering the gold from cloth and clothes embroidered with the metal. He recommends that the garments be burned and the ashes stirred up in a vessel with water and mercury, and that the amalgam be placed in a cloth and squeezed, whereby, he says, "the mercury passes through while the gold, coagulated by the pressure, remains pure within."

Geber[3] (8th century) says "Mercury sticks easily to three minerals, viz., lead, tin and gold; with more difficulty to silver, and with still greater difficulty to copper, but to iron in no manner except through artifice." Paracelsus gives directions for the preparation of copper amalgam by precipitating the copper from the solution of the sulphate by iron, and then mixing it with mercury.

The preparation of an iron amalgam was the cause of much la-

[1] "On Minerals." [2] Conspectus Chemiæ. [3] Summa Perfectionis Magisterii.

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bor on the part of the alchemists, and a task which Geber pronounced very difficult. It appears that the first instructions for its preparation were given by Libavius (1606) in the second part of his Commentariorum Alchemiæ in his treatise De Natura Metallorum. He says that metals frequently fail to combine with mercury on account of impurities and that by proper purification he can amalgamate iron. His directions, however, are somewhat obscure. Brandt[1] in 1751 wrote that the iron amalgam could be prepared by rubbing iron with mercury under a solution of ferrous sulphate, but he said the iron very easily separated from the mercury again. Vogel[2] (1789) gave similar instructions advocating the use of alum in place of the ferrous sulphate; while he had already given a method (1783) of preparing it by rubbing zinc amalgam with ferrous sulphate and water.

While it is now well known that the formation of an amalgam is frequently accompanied by a reduction of temperature, the early chemists made the opposite assertion. The first observation of temperature reduction was made by Demachy[3] in 1774, when he found that such was the case in the amalgamation of tin, or the mixing of lead and bismuth amalgams. Little or no investigation was made along this line however until 1860, when J. Regnauld[4] found that heat was absorbed in the amalgamation of zinc and evolved in the amalgamation of cadmium. In a later investigation, Regnauld[5] found that amalgamation caused metals to change their places in the electro-chemical series, and that in combining with mercury, if heat is absorbed the resulting amalgam became more electro-positive than the metal, and if heat is evolved it became less electro-positive. In the first class he placed zinc, lead, tin, iron, nickel and cobalt; and sodium, potassium and cadmium in the second class. Phipson[6] in 1866 found that if 207 parts of lead, 118 of tin and 284 of bismuth are amalgamated with 1617 parts of mercury at 17°, the temperature of the mixture will be reduced to —10°.

Berthelot[7] in 1880 made investigations tending to indicate the constitution of the potassium and sodium amalgams. He examined the chemical constitution of the liquid and solid amalgams of the alkali metals by treating them with dilute hydrochloric acid, meas-

[1] Proc. Stockholm Acad., 1751.
[2] Crell Chem. Ann., 2, 309.
[3] Recueil de dissertations physico-chim., 1774.
[4] Compt. Rend., 51, 778.
[5] Compt. Rend., 52, 533.
[6] Bull. Soc. Chim. (2) 5, 243.
[7] Compt. Rend., 88, 1335. Compt. Rend., 89, 465.

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uring the heat disengaged by the reactions and analyzing the solution to determine accurately the quantity of the alkali metals present. From the results obtained he deduced the heats of formation. He found that for one equivalent of potassium, the heat increases with a corresponding decrease in the number of mercury molecules until a maximum is reached, when it begins to decrease. The maximum heat of formation, 34°.2, corresponds with a crystalline amalgam containing 1.6 per cent. of potassium and having the formula $Hg_{12}K$.

As the number of mercury atoms is so large, he considers that some of them may play the same part as that of water in a saline hydrate. He obtained no other crystalline amalgam of potassium, but from his results on the heats of formation he concluded that several others existed.

The heats of formation of the sodium amalgams follow a similar order to those of potassium, giving the formula Hg_6Na for the crystalline compound; and, as in the case of potassium, the existence of other compounds was indicated. He also found that the heat of oxidation of the amalgams rich in potassium exceeds that of those rich in sodium, as do also the heats of formation, and that the relative affinities of the free alkalies in these amalgams are inverted. This, he thinks, serves to explain the apparent anomaly observed by Kraut and Popp,[1] that sodium displaces potassium in a solution of potash when it is treated with sodium amalgam, the final result being the formation of the crystalline amalgam $Hg_{12}K$. In a later research he determined the heats of absorption on dissolving $Hg_{12}K$ and Hg_6Na in different quantities of mercury, and he came to the conclusion that the solution of definite amalgams in different quantities of mercury absorbs a constant amount of heat, like the solution of salts in water. He concluded also that there were two more amalgams of each of the alkali metals in question; and, from experiments in which he observed the quantities of heat evolved upon the progressive addition of the alkali metal, he concluded that one of the potassium amalgams has the formula Hg_4K, while the formula of the one richest in potassium he could not calculate with any degree of accuracy. The two additional sodium amalgams received from him the probable formulas Hg_4Na and Hg_7Na_4.

Calvert and Johnson[2] in 1859 and also in 1864, published some

[1] Ann. Ch. Pharm., 159, 188. [2] Proc. Roy. Soc., 10, 14. Phil. Mag. (4), 18, 541.

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of their results on the determination of the heat conductivity of pure mercury and the amalgams. The determinations were confined to the tin, zinc and bismuth amalgams. The tin amalgam proved to be the best conductor, while the bismuth amalgam gave the lowest figure; but in each case the conductivity increased with the decrease in the percentage of mercury in each amalgam.

The electrical conductivity of amalgams has been investigated by Matthiessen and Vogt,[1] Sabine,[2] Weber,[3] and others. Weber's researches were confined to the amalgams of tin, lead, bismuth and cadmium. The results show that the presence of a small quantity of a foreign metal in mercury causes a rapid decrease in the resistance. The conductivity of the amalgam is not the mean conductivity of its constituents. The alloys of mercury with bismuth and lead, however, conduct better than either of their composing metals. The amalgams of the above-named metals form two groups composed of zinc and cadmium, and lead and bismuth respectively. Upon adding zinc or cadmium to mercury the resistance rapidly decreases as the per cent. of the metal increases, and more and more approaches a fixed limit. In the bismuth and lead amalgams the resistance decreases to a minimum and then rises to a maximum. In amalgams and other alloys, points of maxima and minima occur, corresponding to definite chemical combinations.

In 1850 Joule[4] read a paper before the British Association for the Advancement of Science giving an account of his experiments in preparing amalgams electrolytically, by which means he prepared both iron and copper amalgams. He also exhibited a small apparatus whereby he could subject an amalgam to a pressure of sixty tons and thus squeeze out the excess of mercury, leaving an amalgam of approximately definite chemical composition. About ten years later he published[5] his experiments more in detail. He desired to make a perfectly true and polished surface; and to that end he attempted to plate a surface of mercury with iron, supposing that the two metals would not enter into combination. He found however that an amalgam was produced. He then proceeded to prepare the amalgam in order to determine its constitution. He analyzed this, as he did other amalgams which he prepared and studied, "by heating them in a glass tube through which a current

[1] Ann. Phys. Chem. (1), 116, 369.
[2] Phil. Mag. (4), 23, 457.
[3] Ann. Phys. Chem. (2), 31, 243.
[4] Brit. Assoc. Rep., 1850, 55.
[5] Manch. Mem. (3), 2, 115.

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of hydrogen was passed." In consequence of the use of this method I may say that his results for the mercury are probably too low. The amalgam of iron containing an excess of mercury was subjected to pressure as high as fifty tons, and an amalgam was obtained, which upon analysis he found contained mercury and iron in the proportion of 100 to 103.2 parts. He also found that iron amalgams, no matter what the proportion of mercury was, exhibited magnetic properties; and he concluded from experiment that iron suffered very little loss of its magnetic virtue by amalgamation. With copper he obtained a beautiful crystalline amalgam by electrolysis, in which he found mercury 100 parts and copper 27.76 parts, having a specific gravity of 13.17. He subjected the copper amalgam to various pressures for different lengths of time, and he tabulates the results of twenty-one experiments and says "On inspecting the above table, it will appear that a moderate pressure continued for a short time leaves a binary compound of the metals along with the quantity of the mercury which may be supposed to be entangled among the crystals. When the pressure was very great, or was continued for a long time, the resulting amalgam invariably contained more than one equivalent of copper. I believe that this arises from a decomposition of the binary amalgam by the violent mechanical means adopted:" He meant by "moderate pressure," from nine to twenty tons, and by "short time," from a "few minutes" to thirty minutes. In these experiments he used pressure as high as one hundred and forty-four tons per square inch for "a few minutes" time.

He prepared a silver amalgam by the action of silver nitrate on mercury, which produced a hard mass of shining crystals to which he gave the formula AgHg. He also found that under a pressure of seventy-two tons the amalgam contained 43.71 of silver to 100 of mercury. Amalgams of platinum, zinc, lead and tin were also prepared. He concluded from the specific gravities of the various amalgams that considerable contraction in volume took place in the formation of the copper, silver and zinc amalgams, and little or none in platinum and lead.

Joule made an unsuccessful attempt to amalgamate hydrogen by developing it at a low temperature (0°.F) on mercury. He considered however that the experiment was worth repeating and thought that at a very low temperature and high pressure such an amalgam might be obtained.

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In the conclusion of his last paper he says, "As metals generally retain their specific gravities when they meet to form alloys, it may be inferred that the foregoing experiments indicate the specific gravity of mercury in the solid state. This value from the average of thirty-six determinations of specific gravity above given, is 15.19." The value he obtained from the copper amalgams was 14.985, while the latest determinations of solidified mercury put the specific gravity at 14.931.

Henry[1] found that if finely divided gold was treated with mercury and the excess of the latter removed by pressing it through chamois leather, the residue upon treatment with hot nitric acid would, after all of the free mercury had been dissolved, leave yellow shining crystals having the formula Au_8Hg. These crystals are not decomposed by boiling in hot concentrated nitric acid. If an amalgam containing about five per cent. of gold is heated for several days to about 80° and then treated with hot nitric acid, a mass of crystals of considerable length may be obtained. By this means I have obtained needles as long as 1.5 cm.

De Souza,[2] in 1875, began to study the effect of constant temperatures on some amalgams. He heated silver amalgam in the vapor of boiling sulphur until it no longer lost weight, and upon analysis the compound was found to be represented by $Ag_{18}Hg$. Gold amalgam under similar treatment possessed the formula Au_9Hg. In 1876,[3] he repeated his former experiments, verifying the results then obtained. He also heated the amalgams in atmospheres of boiling mercury and diphenylamine. Gold amalgam at the temperature of boiling mercury had the formula Au_9Hg; while in the vapor of diphenylamine less mercury was driven off, and the formula was found to be Au_8Hg. Silver amalgam was represented by $Ag_{11}Hg$ in mercury vapor, and Ag_4Hg in diphenylamine. Copper amalgam was found to possess the formula $Cu_{16}Hg$ in the vapor of boiling sulphur, $Cu_{14}Hg$ in the vapor of boiling mercury and the same in diphenylamine. Potassium amalgam was represented by K_2Hg in the vapor of boiling sulphur; sodium amalgam Na_3Hg after similar treatment, and lead analgam Pb_8Hg, heated to the temperature of boiling mercury. Later, Merz and Weith[4] repeated De Souza's experiments, modifying his methods to some extent; but their results were by no means confirmatory. They exposed amal-

[1] Phil. Mag. (4), 9, 468.
[2] Ber. Deut. Chem. Ges., 8, 1616.
[3] Ber. Deut. Chem. Ges., 9, 1050.
[4] Ber. Deut. Chem. Ges., 14, 1438.

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gams of gold, silver, copper, lead, tin, bismuth, zinc, cadmium, sodium and potassium to temperatures of boiling sulphur, boiling mercury and boiling diphenylamine for several hours, and found in every instance that the mercury was almost, if not wholly expelled, the amalgam having been decomposed. In each case they began the heating upon the amalgam containing from sixty to eighty per cent of mercury and continued it until there was practically no longer any loss of weight. The amalgam of sodium and potassium parted with the mercury slowly; the latter, however, more easily than the former. A stream of an indifferent gas was passed over the amalgam during heating. In the case of the alkalies, the investigators generally employed hydrogen, but sometimes nitrogen, fearing that the hydrogen might possibly combine with the alkali in the amalgam. They found, however, that such was not the case, at least the combination was only momentary and upon analysis an appreciable amount of hydrogen was not recognized; and yet it was found that the mercury was more rapidly given off in a current of hydrogen than in nitrogen. As the result of their work they concluded: (1) that amalgams under a moderate heat undergo decomposition; (2) that gold and other amalgams lose almost all, if not all, of their mercury at the boiling point of mercury; (3) that the small amount of mercury retained is due to mechanical attraction and not to chemical affinity; (4) the fact that mercury can be pressed out of many amalgams indicates that they are molecular compounds; (5) that of the metals, sodium and potassium have the strongest affinity for mercury.

It would seem from the description of the apparatus which they used, that the temperatures to which the amalgams were subjected were considerably higher than should have been obtained in the vapors of the boiling substances employed, for the reason: (1) that the apparatus was too small; (2) the tube containing the amalgam was too near the boiling substance; and (3) if the description of the apparatus be understood, the substance must have been boiling under more or less pressure.

I have repeated the experiment of De Souza upon the gold amalgam in an apparatus of my own design and at the temperature of boiling mercury. The amalgam after arriving at constant weight was represented by the formula Au_9Hg, which is the same as that he obtained. This result has also been verified by Schnauss.[1] I have

[1] Arch. Pharm. (3), 6, 411.

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not had the opportunity, however, of heating the amalgam in a stream of hydrogen or nitrogen as did Merz and Weith, so that I cannot pass final judgment upon the cause of the discrepancy in their results; but from the statement that they make, *i. e.*, that in the case of sodium and potassium amalgams, the mercury is more rapidly expelled in a current of hydrogen than in a current of nitrogen, I may be justified in asking if the passage of even hydrogen or nitrogen over the amalgams may not cause their decomposition? These gases, usually so indifferent, may not be so in this case. There may exist some affinity on the part of the hydrogen or the nitrogen for the mercury or the metal associated with it, which, though very feeble, is sufficiently strong when assisted by heat to overbalance the weak affinities in the amalgams.

Merz and Weith also obtained some interesting results on the melting points of the amalgams of sodium and potassium, and they conclude that the melting point bears no relation to the percentage of the alkali metal in the amalgam. It was frequently found that part of the amalgam would melt first, the portion remaining having a higher melting point. A sodium amalgam, containing 3 per cent. of sodium, melted at 152°–160°; with 4.7 per cent. of sodium the amalgam melted at 305°–315° which was the maximum, and as the proportion of sodium increased the melting point decreased; and finally, an amalgam containing 37.9 per cent. of sodium melted at about the same temperature (152°–159°) as that containing 3 per cent. With the potassium amalgam similar phenomena were observed; that containing 2.7 per cent. of the alkali metal melted at 75°, and the melting point increased with the amount of potassium up to 9.8 per cent. when it was observed to be 240°–245°; it then became lower as the percentage of the potassium increased, and with 29.8 per cent. it melted at 147°–152°. If 4 to 5 per cent. of sodium be added to mercury heated to 250° under paraffin, a solid amalgam will result, but with the addition of a few per cent. more of sodium the whole mass will become liquid, and if mercury is then added, it will again become solid. Potassium under similar conditions will act in a similar manner.

Wanklyn and Chapman,[1] in 1866, succeeded in producing a magnesium amalgam, by heating the metal with mercury nearly to the boiling point of the latter. Under these circumstances the combination took place with considerable violence, while a piece of po-

[1] Jour. Chem. Soc., 19, 141.

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ished magnesium combined with mercury, slowly in the cold. On exposure to the air they found that the magnesium in the amalgam would oxidize rapidly, the mass swelling up and becoming quite hot if moistened with water. It decomposed water violently when immersed in it. These facts are interesting, as it will be noticed that the chemical activity of magnesium is increased by amalgamation, while that of sodium and potassium is much diminished. In this respect aluminum seems to behave like magnesium, for according to Casamajor[1] who prepared the aluminum amalgam by placing aluminum and a zinc rod in contact with mercury and covering them with acidulated water, the aluminum amalgam when dry became quite hot, the mercury appearing to boil, and the surface becoming rapidly coated with a white incrustation of aluminum oxide.

The constitution of ammonium amalgam was, for a time, much discussed and many opposing views were held. It was discovered about the same time by Seebeck[2], and Berzelius and Pontin.[3] Wetherill[4] supposed that when sodium amalgam acted upon a solution of ammonium chloride, the sodium first acted on the water, evolving hydrogen and forming sodium hydroxide, which would in turn set ammonia free, and that the molecules of hydrogen and ammonia thus liberated would, by some means, be retained in the mercury and form a spongy mass. During the winter of 1863–4, in the laboratory of the Smithsonian Institution, he proceeded to prove his hypothesis by experiment. He found that the hydrogen evolved by sodium amalgam in hydrochloric or sulphuric acids and also in potassium hydroxide solution would not cause the mercury to swell; but that this phenomenon would immediately take place upon the addition of a small quantity of ammonium chloride. He also found that hydrogen developed by sodium amalgam in a solution of ammonia would not produce turgescence. Hence, he concluded that both the hydrogen and ammonia should be in a nascent state. The ammonium amalgam was obtained by him from solutions of the chloride, oxalate, carbonate, sulphate and bisulphate, but he could not obtain it from the nitrate, even by the aid of electrolysis. He subjected the amalgam to pressure between two glass plates and obtained a reticulated film owing to the bubbles of the escaping gases from the constantly decomposing amalgam, and from this he

[1] Amer. Chemist, 6, 450.
[2] Gehlen neu. Allg. Jr. Ch., 5, 432.
[3] Gilbert's Ann., 6, 260.
[4] Sill. Amer. Jour. (2), 40, 160.

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drew the conclusion, that the so-called amalgam was merely mercury with these gases incorporated. From these and some other experiments, he concludes: (1) "the so-called ammonium amalgam is not an alloy of mercury and ammonium; (2) the swelling of the mass in the phenomenon is due to the retention of the gas bubbles, and (3) the coherence of the gases and liquids concerned is changed from the normal condition, exhibiting phenomena which may be classed with those of catalysis."

Pfeil and Leffman[1] treated a saturated solution of the hydrochloride of trimethylamine with sodium amalgam and obtained phenomena similar to those which occur in the preparation of ammonium amalgam. The turgescence, however, rapidly subsided, hydrogen being given off, and trimethylamine was contained in the liquid. Wetherill[2] had previously recorded a similar result with the oxalate of methylamine. Pfeil and Leffman treated solutions of aniline, conine, morphine and quinine hydrochlorides and also the acetate of rosaniline with sodium amalgam and no turgescence was observed, although hydrogen was copiously evolved. They also found that when a solution of ammonium chloride in pure glycerine was treated with sodium amalgam, ammonium amalgam was formed, but the swelling of the mass was interfered with, and that if sodium amalgam be brought in contact with a crystal of ammonium chloride, no action ensued until it was moistened with water. The authors considered that the results which they obtained coincided with those of Wetherill and afforded additional evidence that the ammonium group does not alloy with mercury.

Seely[3] considered the ammonium amalgam a mechanical mixture of ammonia and hydrogen in mercury for the following reasons: (1) that the volume of the ammonium amalgam cannot be explained in any other way; (2) that no solid or liquid chemical compound nor any amalgam is analogous to it. He says "mercury has a polished surface while the ammonium amalgam possesses a duller and whiter appearance, like unpolished silver." "It is like a foam and if subjected to varying pressure the volume changes with it and evidently according to Mariotte's law;" this he attempted to prove, in a very crude way, by subjecting the amalgam to pressure in a tube fitted with a piston, when he found that it was condensed to the original volume of the mercury, taking on the appearance of

[1] Sill. Amer. Jour. (2), 42, 72. [2] Sill. Amer. Jour. (2), 40, 160.
[3] Chem. News, 21, 265.

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that metal, and on relieving the pressure it returned to the original bulk. He finally came to this unique conclusion, viz., that ammonium is not a metal, and that if the monovalent radical does exist, it is not a solid nor a liquid but a gas.

It is unnecessary to comment upon the weak points in the researches upon the nature of the ammonium amalgam which I have just outlined, nor is it worth while to pause longer upon their conclusions, as they have only an historical interest.

Davy[1] analyzed the gases evolved by decomposing ammonium amalgam and found them to consist of hydrogen and ammonia in the proportion of one volume to two, while Gay-Lussac and Thénard[2] obtained from the amalgam prepared by electrolysis twenty-three volumes of hydrogen to twenty-eight volumes of ammonia; and from that prepared by means of potassium amalgam, 1 volume of hydrogen to 2.5 volumes of ammonia. These conflicting results led Landolt[3] in 1868 to redetermine the proportion of the gases evolved, and the result he obtained was 1 volume of hydrogen to 2.15 volumes of ammonia. His results, which agree fairly well with Davy's, led him to believe that the ammonia and hydrogen are combined with the mercury in the proportion required to constitute ammonium, and therefore that the ammonium amalgam is the result of a chemical union between ammonium and mercury. He also found that the proportion by weight of mercury to ammonium, in a saturated amalgam, was 106 parts of mercury to .09 parts of ammonium. Landolt also endeavored to determine whether the ammonium group possessed metallic properties. He argued as sodium and potassium amalgams, if thrown into solutions of many metallic salts, would be decomposed, the metal precipitated and an amalgam be formed, that the ammonium amalgam should exhibit the same behavior. He found that it would not precipitate the metals as did sodium and potassium amalgams. He rightly concluded, however, that this did not prove the non-existence of a true ammonium amalgam, but simply showed that the ammonium, when set[4] free, was decomposed into ammonia and hydrogen. Routledge, in 1872, redetermined the comparative volumes of ammonia and hydrogen in the gases evolved from ammonium amalgam, as he had come to the conclusion that Landolt's results were inaccurate on account of the manipulation to which the latter subjected the amal-

[1] Phil. Trans., 1808, 353; 1810, 55.
[2] Rec. Physico-Chim., 1, 63.
[3] Ann. Chem. Pharm. Sup., 6, 346.
[4] Chem. News, 26, 210.

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gam. He obtained the following result: 1 volume of hydrogen to 1.97 volumes of ammonia, substantially confirming those of Davy and Landolt. He also determined the change of volume of the amalgam, which took place under different pressures, and concluded that the compressibility of the amalgam results from the pressure of free gases, due to its decomposition. Thus it appears that the question as to whether or not the ammonium amalgam is a chemical compound of the radical ammonium and mercury, is definitely settled in the affirmative. There seems to be as good reasons for the existence of a compound of ammonium and mercury, as for those of the well known compounds of mercury with the various alcohol radicals.

Several attempts have been made to prepare an amalgam of hydrogen and mercury; that made by Joule having already been referred to. Döbereiner[1] and Loew[2] claim to have prepared it. The latter found that when zinc amalgam was shaken with water, a slow decomposition took place, and flocculi of zinc hydrate were formed, with the evolution of hydrogen. The decomposition was hastened if a small quantity of platinic chloride was added,—and at the same time a substance was formed on the surface of the undecomposed zinc amalgam, which he supposed to be an alloy of hydrogenium and mercury. To obtain it on a larger scale he took an amalgam containing five per cent. of zinc and warmed it until it fused, and then shook it up with an equal volume of a ten per cent. solution of platinic chloride, taking care to keep the mixture cool. The zinc amalgam swelled up considerably, and continued to evolve hydrogen until it was entirely decomposed. The hydrogenium amalgam thus prepared was pressed between sheets of filtering paper. When spread out in a layer (not too thin) in the air, the temperature soon rose considerably and the vapor of water was formed, which was condensed in a glass receiver. He considers that the finely divided platinum present in the amalgam was the cause of this rapid oxidation of the hydrogen. He says further that by the action of the platinic chloride on the zinc amalgam the oxychloride of zinc is produced, which may be removed by hydrochloric acid but greatly at the expense of the hydrogenium amalgam, and if washed with water the remainder undergoes slow decomposition with increase in volume. He thinks that the presence of zinc amal-

[1] Thomson's Annals, 6, 234; 7, 30. [2] Sill. Amer. Jour. (2), 50, 99.

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gam, and also of sodium amalgam, greatly accelerates the decomposition. From these results Loew draws the conclusion, strangely enough, that hydrogenium is analogous to ozone, and consequently, that it may be represented by the formula H_3 as ozone is represented by O_3, instead of inferring what seems to be more natural, viz., that hydrogenium behaves like a metal.

Regnauld found that the specific heat of an alloy is equal to the mean of the specific heats of its components. Exceptions to this rule exist in certain bismuth, tin and lead alloys, and Spring has since shown that certain cadmium, tin, lead and bismuth alloys and amalgams also, do not conform to the above rule. In the case of the alloys, Wiedemann[1] thinks that these differences may probably be explained by the occurrence of molecular changes accompanied by the evolution of heat, while in that of amalgams it would appear that they are a mixture of a solid and a fluid, the proportions of which vary with the temperature. To prove this, two amalgams, SnHg and Sn_2Hg, were examined with tin as a comparison, at high temperatures. Both amalgams cooled nearly as rapidly as the tin, showing the specific heats of the tin and the two amalgams to be nearly the same, which would be the case according to Regnauld's law. The SnHg and Sn_2Hg, at 128° and 164° respectively, behaved in the same manner as the lead alloys in the neighborhood of their so-called second melting point; but the temperature did not appear to remain constant at a fixed point for any length of time, as it did for seven minutes in the case of the tin-lead alloy. The so-called second melting-point Wiedemann considered to be the temperature at which the metal dissolved in the alloy begins to be deposited on cooling; but it seems to me that the metal itself would not be deposited, but a richer alloy would separate, or crystallize out, from the molten mass. I have previously referred to the fact noticed by Merz and Weith, that in fusing sodium and potassium amalgams a portion melts first and finally the remainder becomes fluid.

From the résumé of the more important researches on the nature of amalgams which I have briefly outlined, it seems to be proved that amalgams are chemical compounds, more or less unstable. The fact that heat is absorbed in the amalgamation of a metal, does not argue against the chemical nature of the resulting combination,

[1] Ann. Phys. Chem. (2), 3, 237.

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for the excess of mercury, dissolving the amalgam as it forms, absorbs more heat than is produced in its formation.

In the presence of an excess of mercury, the nature of the resulting mixture is not so well understood, although many facts are known which seem to indicate that the amalgam dissolves in the mercury to a certain extent. The fact that a large part of the amalgam may be separated from the excess of mercury by straining it through chamois leather, or other porous material, certainly indicates that the portion so removed is not in solution. I have found that if mercury containing 0.1 per cent. of gold be placed in a tall cylinder and allowed to stand quietly for several months, a portion of the gold amalgam will settle to the bottom, as an analysis of the mercury taken from the top showed that it contained only 0.0683 per cent. of gold. The temperature during the time of settling averaged about 20°C. Thinking that even this small quantity of gold might be some of the definite amalgam in suspension and not in true solution, I filtered some of it through boxwood and on analyzing the mercury thus filtered I found it to contain 0.0601 per cent. of gold. This seems to indicate that mercury will dissolve only about 0.06 per cent. of gold at 20°C., and that a greater amount than this in mercury at that temperature is the definite amalgam in suspension.

The definite amalgams are, as far as they are known, crystalline in structure, and it may be that instead of dissolving in mercury as a salt does in water, *i. e.*, breaking down to the molecule, the mercury disintegrates the amalgam to nothing smaller than the crystal unit, so that when the mercury is squeezed through chamois leather the crystal units which have collected together in masses of sufficient size cannot pass through the pores of the skin, while the smaller masses and the single crystal particles are not held back; but if the mercury be forced through boxwood or material having smaller pores, more of the amalgam refuses to pass through.

I append hereto an index to the literature pertaining to the subject, and although it may not be complete, I can say that I have endeavored to make it so. I give first a list of the more important references (with the titles) which deal with the subject in a more or less general way. Under the respective metals will be found the references which relate to them specially.

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Regnauld; Compt. Rend. **51**, 778.
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ZIRCONIUM.

Davy; Phil. Trans. 1808, 352.

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PAPERS READ.

ESTIMATION OF BROMINE IN PRESENCE OF CHLORINE. By Prof. A. B. PRESCOTT and W. L. DUNN, Ann Arbor, Mich.

FOR estimation of bromides taken in mixture with chlorides indirect methods of analysis have been, until within about ten years, almost the only trustworthy dependence. The reactions used for actual quantitative separation did not go further than removal of an excess of the chlorides to obtain a concentration of the bromides preparatory to their final estimation. In late years, however, trial has been made of certain reactions for complete separation, in methods of direct analysis, and it can no longer be said that every direct method is unsafe. Seeking, first, the best of the known methods for indirect estimation, and then the best of the proposed methods for direct estimation, the writers have undertaken a set of control analyses with each method so adopted, and the results are given below.

I. For an *indirect estimation*, starting with a weighed quantity of silver bromide and chloride, as the one factor, it was decided to take metallic silver as the other required factor. The reduction to metallic silver was adopted, after collating the authorities, as capable of closer results than those obtained by conversion of the mixed bromide and chloride to entire chloride of silver according to Wittstein[1] and others; or conversion to entire bromide of silver by digesting with potassium bromide solution according to Field,[2] Siewart,[3] or Huschke,[4] these methods providing for estimation of iodide as well. The conversion first to bromide and then to the iodide, by intervention of cyanide solution, after Maxwell-Lyte,[5] though favorably reported upon by Whitfield,[6] is certainly more complex than conversion to metallic silver. The reduction of the silver haloids by heating in a stream of hydrogen, according to the earlier directions of Fresenius, was never wholly satisfactory, and may well be superseded by electrolytic reduction. At an early period the electrolysis of the fused mass was proposed by Bolley.[7] Careful control analyses were made, a few years ago, by Kinnicutt,[8] who applied the poles to the fused mass covered with dilute sulphuric acid. A more favorable condition for the electrolysis is that of the cyanide solution of the silver haloids,[9] a solution obtained directly from

[1] G. C. WITTSTEIN, 1863: *Zeitsch. anal. Chem.*, **2**, 157; Fresenius's Quantitative Anal., London, 1865, p. 441.
[2] F. FIELD, 1868: *Jour. prakt. Chem.*, **73**, 404.
[3] M. SIEWART, 1868: *Zeitsch. anal. Chem.*, **7**, 469.
[4] OTTO HUSCHKE, 1868: *Zeitsch. anal. Chem.*, **7**, 434.
[5] MAXWELL-LYTE, 1884: *Chemical News*, **49**, 3; *Am. Chem. Jour.*, **6**, 352.
[6] *Am. Chem. Jour.*, **8**, 425.
[7] BOLLEY, 1859: *Ding. polyt. Jour.*, **151**, 46.
[8] L. P. KINNICUTT, 1882: *Am. Chem. Jour.*, **4**, 22; *Jour. Chem. Soc.*, **42**, 722.
[9] LUCKOW, 1865: *Ding. polyt. Jour.*, **178**, 43.

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the argentic precipitate, whereby fusion and its disadvantages are avoided. Mr. Whitfield of the U. S. Geological Survey has recently subjected the plan to a careful trial, and with his report[1] has given a good account of methods hitherto in use. He found good results by the deposition of metallic silver from the cyanide solution; also good results by the precipitation of silver iodide from the same solution. And the directions given by Whitfield[2] were taken as an outline of the operation for indirect analyses, in this work, the operation being finally adjusted as follows.

Of the mixed chloride and bromide, five grams were taken. The complete silver precipitate, obtained as required in gravimetric work and carefully protected from the light, was filtered through a weighed asbestos filter. The filter found best for this purpose is prepared as follows: A carbon-tube[3] is selected, a light plug of absorbent cotton is placed in the bottom, and then a layer of very thoroughly washed asbestos about one-fourth of an inch in thickness. The filter was dried, to a constant weight, in an air-bath at 150°C., cooling in a desiccator. The precipitate well washed on this filter was dried at same temperature in the same bath and weighed under equal conditions, to obtain the weight of the silver chloride and silver bromide. The precipitate is then dissolved on the filter by application of potassium cyanide solution, using least possible quantity of the solvent, while completely washing out the solution into a weighed platinum dish, which is in contact with the negative pole of a battery of two Bunsen cells. The positive electrode is introduced into the solution, but not brought in contact with the dish. The current is continued until the solution is destitute of silver, as shown by a drop of the solution taken upon a glass slide, over a dark ground, remaining entirely clear while treated with a drop of hydrochloric acid. As soon as the silver is completely deposited, the dish is removed from the battery, drained and several times washed with water, to prevent the solvent action of the cyanide upon the metallic silver. The dish with the silver deposit is dried in the air-bath, cooled and weighed. For both weighings of the dish its temperature is equalized in the balance-case.

The results of *seven* control analyses by this method, in the indirect way, are given further on.

II. For a *direct estimation*, the separation of the bromine by the action of chromic acid, in distillation, was adopted. The reactions of chromic acid with chlorides, bromides and iodides, under specific conditions, have been reported upon[4] for many years. Adaptation to the quantitative separation of the haloids was made by Dechan in 1886,[5] who sets forth what was partly shown by Donath, that having dichromate in proper concentra-

[1] J. EDWARD WHITFIELD, 1886: *Am. Chem. Jour.*, 8, 421; *Jour. Chem. Soc.*, 52, 525.

[2] Where last cited.

[3] In the form of a test-tube of full width, perforated on the bottom, where a section of glass-tubing is fused on, over the perforations, serving as a funnel-neck.

[4] WOHLER, 1834: *Ann. Phys. Chem. Pogg.*, 33, 343.
DONATH, 1880: *Zeitsch. anal. Chem.*, 19, 20.

[5] M. DECHAN, 1886: *Jour. Chem. Soc.* (Trans.) 49, 682.

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tion, on boiling, iodine is liberated from iodides and distilled over in complete separation from bromine. Then, on adding sulphuric acid in due quantity, and maintaining a certain concentration, bromine is all distilled over while all chlorine is left behind, greater concentration being required to distil any chlorochromic anhydride. As finally adjusted in this experimentation, the process is as follows:

A distilling flask of fully 150 c.c. capacity admits a separatory funnel, closed with a stop-cock, the funnel-tube reaching the bottom of the flask. The vapor-tube of the distilling flask, bent just above the stopper to a line slightly descending for four or five inches and then turned down vertically, forms the inner tube of an upright Liebig's condenser of about eight inches length, when it passes to the bottom of a receiving flask of about 100 c.c. capacity and with twice tubulated stopper, the second tubule connecting with an aspirator. The distilling flask is adjusted on a retort-stand over a small Bunsen burner directly applied. Of potassium dichromate fifty grams are placed in the distilling flask, and 100 c.c. of distilled water are added, with 0.5 to 1.0 gram of the haloids, the material in which the bromine is to be estimated. With very low percentages of bromine there may be taken 2.0 grams of the material. The distilling flask being in position, connected with the vapor tube and the receiving flask, heat is applied until the dichromate is all dissolved. If iodine be present, the distilling liquid is boiled, with the aspirator in action and the funnel-tube open, until the distillate ceases to turn starch water blue, when, if desired, the iodine can be estimated as directed below for bromine. The receiving flask is now cleaned and charged with 10 c.c. of thirtieth normal solution of arsenious acid; the distilling flask is charged with 10 c.c. of sulphuric acid previously diluted to 20 c.c.; and the distilling liquid is boiled, while the aspirator is in action, the funnel-tube open, and the condenser kept cold. The contents of the distilling flask are maintained at a volume of 100 to 120 c.c. After boiling about an hour, the flame is removed, the receiving flask detached, with rinsing of the delivery tube, a test-tube containing some drops of potassium iodide solution and starch water placed as a receiver, and the flame replaced until the distillate is tested for absence of bromine. When the distillation is complete, the contents of the receiving flask are titrated with thirtieth normal solution of iodine, this solution having been compared with that of arsenious acid. The quantity of iodine used is calculated into its equivalent of bromine.

Other methods of direct estimation depending upon the action of oxidizing agents other than chromic acid, upon the graded differentiation of the haloids, are methods[1] with permanganate, manganese dioxide and

[1] MOHR, manganese dioxide, 1855: *Ann. Chem. Phar.*, **93**, 80.
VORTMANN, manganese and lead dioxides, 1880: *Ber. d. chem. Gess.*, **19**, 352.
BERGLUND, Vortmann's method, 1885: *Zeitsch. anal. Chem.*, **24**, 196.
BERGLUND, use of permanganate, 1885: *Zeitsch. anal. Chem.*, **24**, 184.
E. HART, permanganate in qual. anal., 1885: *Zeitsch. anal. Chem.*, **24**, 182.
CAZAZZI, on barium dioxide, 1886: *Gaz. Chim. ital.*, **13**, 174.
COOK, use of hydrogen peroxide. 1885: *Jour. Chem. Soc.*, **47**, 472.
SCHOENE, the same, 1879: *Ann. Chem. Phar.*, **195**, 228.

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hydrogen peroxide. Such a partial separation of the haloids, as has been found serviceable for concentration of bromine, is effected by fractional precipitation with the silver,[1] by solubility of alkali[2] salts in alcohol, and by the manganese dioxide as above.[3]

I. BY INDIRECT METHOD.

	NaCl taken.	KBr taken.	Br taken.	Br found.	Error.	Error per 1 of material.
1	5.000	0.020	0.01343	0.013320	0.000110	0.000022
2	5.000	0.010	0.006715	0 006500	0.000215	0.000043
3	5.000	0.010	0.006715	0.005920	0.000795	0 000156
4	5.000	0.0062	0.005506	0.005405	0.000101	0.000020
5	5.000	0.0062	0.004163	0.003020	0.001143	0.000228
6	5.000	0.0100	0.006715	0.006620	0.000095	0.000019

II. BY DIRECT METHOD.

	NaCl taken.	KBr taken.	Br taken.	Br. found.	Error.	Error per 1 of material.
1	0.480	0.020	0.013431	0.013559	0.000128	0.000256
2	0.480*	0.020	0.013431	0.012862	0.000569	0 001138
3	0.563	0.010	0.006715	0.005583	0.001132	0.001971
4	0.483	0.010	0.006715	0.006431	0.000284	0.000573
5	0.400†	0.010	0.006715	0.006640	0.000341	0.000183
6	0.485	0.015	0.010072	0.009910	0.000162	0.000324
7	0.490	0.010	0.006715	0.006581	0.000134	0.000268

* Of sodium chloride and magnesium sulphate.

† Of sodium and calcium chlorides and sulphates.

In the first four experiments by the direct method, dicinormal solutions of arsenious acid and of iodine were used. The more dilute solutions, thirtieth normal, gave better results.

MOLUGRAMS AND MOLUGRAM-LITRES. By Prof. CHARLES E. MUNROE, Newport, R. I.

[ABSTRACT.]

THE term molugram is proposed for use to designate the number of grams-mass of a substance that is numerically equal to the molecular-mass of this substance referred to its unit. Thus, taking hydrogen as the stand-

[1] FEHLING, 1848: *Jour. prakt. Chem.*, **45**, 269.

[2] MARCHAND, 1849: *Jour. prakt. Chem.*, **47**, 363.

[3] See note on previous page.

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ard of molecular-mass, one molugram of hydrogen equals 2 grams; of oxygen 32 grams; of water 18 grams; of mercury 200 grams, etc. This quantity is generally referred to as the molecular weight of a substance taken in grams, but this method of statement is both awkward and incorrect. The values attached to this term are, however, often very convenient, and I feel that its use will be less confusing if designated by some such term as the above.

The term molugram-litres is proposed for use to designate the volume in litres at 0°C. and 76 cm. of pressure, when in the state of a gas, of the number of grams-mass of a substance that is numerically equal to the molecular-mass of this substance referred to its unit. This value, which is constant for all substances, is 22.32 litres, and it is a most convenient one for use in stochiometrical calculation. By the adoption of this term molugram-litres to designate this value, we may avoid circumlocution while we gain in precision of statement.

THE EXPLOSIVENESS OF THE CELLULOIDS. By Prof. CHAS. E. MUNROE, Newport, R. I.

[ABSTRACT.]

BY celluloids we mean the bodies produced by the action of camphor on the lower cellulose nitrates and which become plastic, so as to be readily molded, when heated to a moderately high temperature. Two varieties are used in the arts, a translucent one and an opaque; the latter being formed by the admixture of zinc oxide and other incombustible, inexplosive materials with the translucent variety, while the translucent variety consists simply of pyroxylin and camphor with various coloring matters, principally of organic origin. The opaque variety is the one which is most largely used in the manufacture of articles for the toilet, wearing apparel, pianoforte keys and the like. Owing to the presence of pyroxylin in these bodies, there is a popular belief that they are explosive, but this is denied by the manufacturers. The books show that similar differences of opinion exist among the writers on this subject.

In this paper are given the results of experiments made for the purpose of testing the "stability," flashing point and explosiveness of the two varieties and the results show that the opaque variety is insensitive to the shock of detonators at ordinary temperatures but that the translucent variety is readily exploded by this means.

A NEW BOTTLE FOR HYDROFLUORIC ACID. By Prof. EDWARD HART, Easton, Pa.

[ABSTRACT.]

THE bottle is a hollow casting made of wax, paraffine, or cerasine, or a mixture of these substances. Cerasine is preferred because of its higher melting point. The stopper is inverted and the mushroom top melted to

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the rim during transportation. When received it is cut apart with a penknife and inverted.

An approximate table of the relations between the specific gravity and percentage composition of aqueous hydrofluoric acid is also given.

[This paper will appear in the Journal of Analytical Chemistry.]

THE CHEMICAL CONSTITUTION OF THE MICA GROUP. By Prof. F. W. CLARKE, Washington, D. C.

[ABSTRACT.]

THE author discusses the chemical structure of the micas, chlorites, vermiculites, etc., and shows that all these compounds are reducible to one general type of formula, under which they become substitution derivatives of aluminum orthosilicate.

FOOD PREPARATION. By Dr. FRED. HOFFMANN, New York, N. Y.

[ABSTRACT.]

ACCORDING to reliable estimates the quantity of artificially manufactured foods used for infants and children amounts in the United States in money value to nearly ten million of dollars.

Whilst the supply and the quality of food are controlled by legal regulations in all civilized nations, there is no such control of the food supply for infants and invalids, as soon as this food is artificially prepared. As these foods are of uncertain composition and quality and to a large extent perhaps prepared without due consideration of correct physiological and chemical principles, there is hardly any doubt that the deficient quality of such commercial infants' food has a far greater influence upon the unusually large mortality rates of infants in our large cities than is generally suspected.

In presenting a printed list of analytical results of such much-used foods as have been analyzed, I simply will call the attention of chemists to this very important matter which deserves a much wider investigation.

SUCCINYLO-SUCCINNIC ACID. By Prof. ADOLPH BAEYER, Munich, Germany, and Prof. W. A. NOYES, Terre Haute, Ind.

[ABSTRACT.]

SOME time since one of us showed that the ethyl ester of dioxyterephthalic acid could be reduced to the ester of succinylo-succinnic acid. Dioxyterephthalic acid had not, hitherto, been reduced. It has been found that the reduction can be easily effected by means of sodium amalgam. In this way succinylo-succinnic acid has been obtained in larger quantities than before and more carefully studied. The acid is very difficultly soluble in

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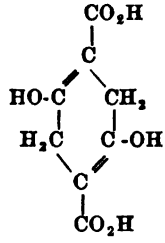
water, requiring more than five thousand parts at 20°. This gives some ground for believing the structure to be that of a $\Delta^{1,4}$ dioxydihydroterephthalic acid.



The ease with which the acid loses carbon dioxide and gives tetrahydrochinone, and the ease with which it reacts with phenyl-hydrazine point, however, to the ketone formula. From tetrahydrochinone (hexamethylene diketone) the dioxime was prepared and from this, by reduction with sodium and alcohol, hexamethylene diamine was obtained. This shows the remarkable stability of what Bamberger calls the alicyclic bases.

The hydrazone of the di-ketone was also prepared and this by reduction gave, probably, *two* hydrazo compounds which appear to be "geometric" isomers. The hydrazone, unlike any hitherto known, shows basic properties, forming weak salts.

ON THE ACQUISITION OF ATMOSPHERIC NITROGEN BY PLANTS. By Prof. W. O. ATWATER, Middletown, Conn.

[ABSTRACT.]

EXPERIMENTS, similar to those reported at the Philadelphia meeting of the Association and described in detail in Vol. IX of the American Chemical Journal, confirm the results of those experiments and of later ones by Hellriegel and others in indicating that some leguminous plants, at any rate, acquire large quantities of nitrogen from the air. In the experiments here reported, the connection between root tubercles and assimilation of nitrogen which has been brought out by Hellriegel is confirmed.

THE COMPOSITION OF ONTARIO OATS. By C. C. JAMES, Professor of Chemistry, Ontario Agricultural College, Guelph, Ont.

ANYTHING that can be added to our present knowledge of the oat plant should prove interesting and serviceable, as there are few agricultural plants more important. It is easily produced, growing upon poor soils, flourishing upon rich soils; it can be made to yield in great abundance, both in grain and in valuable straw; it is an almost universal food for man and beast.

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The following table contains the analysis of ten samples of oats produced in Ontario and used during the present year on the Ontario Experimental Farm, Guelph.

VARIETY.	WATER.	CRUDE PROTEIN.	FAT.	SOLUBLE CARBOHYDRATES.	CRUDE FIBRE.	ASH.
1. Egyptian White.	12.95	9 28	4.83	55.49	14.15	3.30
2. White Australian.	13.60	10.94	4.01	56.75	11.55	3.15
3. Rennie's Prize White.	13.61	9.75	4.13	57.47	12.23	2.81
4. Acclimatized Black Tartarian.	12.40	10.45	5.37	57.50	11.22	3.06
5. Bavarian.	13.30	11.19	5.95	55.57	10.30	3.69
6. Black Champion.	12.75	10.88	4.85	59.61	9.59	2.82
7. Improved Scotch Potato.	13.54	9.19	7.49	57.71	9.11	2.96
8. Cluster or Triumph.	11.53	11.81	6.41	51.97	15.41	2.87
9. Welcome.	12.99	8.53	4.25	61.89	9.23	3.13
10. Early Calder.	12.93	6.19	5.64	55.74	16.33	3.17
Average.	12.96	9.82	5.24	56.97	11.91	3.10

The physical properties of the same samples are partially represented in the following table:

VARIETY.	COLOR.	WEIGHT PER BUSHEL, LB.	WEIGHT OF 100 KERNELS, GRAMS.	NO. OF KERNELS PER BUSHEL.	
1. Egyptian White.	Yellow	39.94	2.829	640,391	moderately long and plump.
2. White Australian.	Dark yellow	38.24	2.894	599,365	
3. Rennie's Prize White.	Yellow	39.61	3.716	483,503	plump, medium length.
4. Acclimated Bl'k Tartarian.	Black	36.80	2.583	646,351	long, thin.
5. Bavarian.	Dark yellow	35.83	3.023	537,625	long, moderately plump.
6. Black Champion.	Dark brown	33.15	2.380	631,790	
7. Improved Scotch Potato.	Yellow	40.43	3.103	591,004	short, plump.
8. Cluster or Triumph.	Light yellow	36.91	3.253	514,669	
9. Welcome.	Yellow	35.19	3.160	505,132	
10. Early Calder.	Yellow	37.78	2.154	795,586	
Average.		37.39	2.910	594,542	

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The average of 166 United States samples as given by Clifford Richardson (Bulletin 9, 1886, Washington, Agricultural Department) shows the following: weight per bushel 37.2 lb.; weight of 100 kernels 2.507 grams.

For comparison with other analyses I shall add the following:—

	Water.	Crude Protein.	Fat.	Soluble Carbo-hydrates.	Crude Fiber.	Ash.
Richardson, 179 samples.	6.42	10.76	6.64	66.67	6.33	3.18
Koenig, 153 samples.	12.37	10.41	5.23	57.78	11.19	3.02
Brewer, 20 samples.	10.56	11.41	4.97	61.10	9.01	2.95
Jenkins, 25 samples.	10.94	11.38	4.81	60.05	9.85	2.97
Average of 10 above.	12.96	9.82	5.24	56.97	11.91	3.10

From which it will be seen that the best Ontario oats are of about the same composition as the German samples analyzed by Koenig.

Some peculiarities of butter. By Prof. H. W. Wiley, Washington, D. C.

[abstract.]

The paper showed some peculiarities in genuine butter which would lead to its condemnation as spurious when judged by the ordinary standards.

These peculiarities are characteristic of butters from certain animals or certain kinds of food. They refer particularly to variations in the content of volatile acids, to changes in melting point, and to the occurrence of certain constituents of the food in the butter.

Composition of the seed of Calacanthus glaucus. (Illustrated.) By Prof. H. W. Wiley, Washington, D. C.

[abstract.]

The paper contained the data obtained in the analyses of the pods, hulls and clean seeds of the Calacanthus.

It also contained a description of a new alkaloid, Calacanthine, first discovered by Dr. Eccles, but not studied by him. The peculiar characteristics of this alkaloid and its chemical reactions were shown.

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DYNAMICAL THEORY OF ALBUMINOID AMMONIA.[1] By Prof. ROBERT B. WARDER, Washington, D. C.

[ABSTRACT.]

I. Free ammonia is distilled in accordance with the equation

$$\log \frac{y}{y_o} = k \log \frac{x}{x_o}$$

where x = volume of fluid in retort,
y = weight of ammonia in retort,
k = coëfficient of volatility,
and zero subscript denotes initial conditions.

II. This formula is compared with determinations by Smart, published by Mallet in the National Board of Health Report for 1882.

III. The law of mass action, under certain (ideal) conditions, leads to the equation,

$$-\log \frac{z_\infty - (y + z)}{z_\infty} = A \frac{x_o - x}{x}$$

Where z = weight of ammonia in distillate,
z_∞ = final weight of ammonia in distillate, and
$y + z$ = total weight of ammonia formed.

IV. Distillation, at the same time, must conform to the equation

$$\dot{y} = -\frac{x}{k} \cdot \frac{dz}{dx}.$$

Curves are shown, representing:
A, distillation of free ammonia.
a, *a*, *a*, successive fractions of free ammonia.
B, formation of albuminoid ammonia, $A = 1$.
C, " " " " $A = 0.1$.
D, distillation of albuminoid ammonia; from curve *B*.
d, *d*, *d*, successive fractions of albuminoid ammonia.
E, albuminoid ammonia in the retort.

V. An exterpolation formula, intended to find a correction for the residue in the retort, gives unsatisfactory results, for reasons explained.

VI. A comparison of theory with the progress noted by Smart, in the case of certain pure chemicals, shows that these are soon partly converted into intermediate products of relatively great stability; hence the difficulty in completing the reaction.

VII. The method of determination devised by Wanklyn is capable of numerous modifications, a few of which have been made by other chemists. The original directions are insufficient to give consistent results, and more definite conditions should be agreed upon.

[1] This paper is printed in full in Amer. Chem. Jour., 11, 365-378 (Sept., 1889).

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ACTION OF LIGHT ON SILVER CHLORIDE. By ROMYN HITCHCOCK, Washington, D. C.

[ABSTRACT.]

As the result of experiments with thin films of silver chloride exposed to light, it was found that there was invariably a loss in weight.

An apparatus was arranged in which thin plates of glass, such as are used for covers of microscopical mounts, covered with translucent films of silver chloride, could be exposed to sunlight in a current of hydrogen gas, and the chlorine set free absorbed in a solution of silver nitrate.

The results obtained were far more uniform than any hitherto reported, no doubt owing to the fact that the chloride was obtained in a condition that permitted the light to act uniformly throughout the film. All experiments made with the chloride in a massive form, such as results from the ordinary method of precipitation and subsequent agitation, either in washing or in passing a current of air through the suspended precipitate, are doubtless vitiated by the protective action of the surface-molecules of the precipitated particles. It was found that even with the thin films used in these experiments, one film would almost perfectly protect another film during a whole day with bright sunlight shining directly upon the plate.

This is the first time that the chlorine set free from silver chloride has been accurately determined by loss in weight and also collected and weighed as silver chloride.

The object of these experiments has been to determine:

1. Whether there is a loss in weight proportioned to the amount of chlorine set free.

2. Whether an oxychloride is formed by the action of light, this being a ready explanation of an obvious loss of chlorine without change in weight. Most experimenters have agreed that there is no loss in weight, but a strong odor of chlorine is noticeable. If an oxychloride is formed, the chlorine collected in the apparatus should exceed in weight the loss sustained by the silver chloride.

The conclusion arrived at is that the loss in weight of 0.100 gramme of silver chloride in sunlight amounts to about 0.005–0.006 gramme, and that the weight of chlorine set free, as determined with the apparatus, is very nearly the same and will probably be shown by subsequent experiments to be exactly the same. Hence, the action of light is to set chlorine free and no oxychloride is formed.

Silver chloride, acted upon by light in these experiments, yields up silver to dilute nitric acid in a relatively large quantity, but the proportion has not been quantitatively determined.

The investigations are not complete.

SPECTRUM PHOTOGRAPHY. By ROMYN HITCHCOCK, Washington, D. C.

[ABSTRACT.]

A GENERAL review of the spectrographic work recently done by Mr. Victor Schumann of Leipzig, where the writer spent several days last winter,

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and an exhibition of a number of photographs on glass, some of them taken with a train of nine quartz prisms. Mr. Schumann has been engaged for many years in studying the ultra-violet lines of metallic spectra, and he has recently constructed a spectograph which will photograph the entire spectrum from λ 760 to λ 185 on a single plane, covering a length of 30 cm., all the lines being sharply defined.

The extreme ultra-violet rays, which have been declared to be unable to pass through a short column of air, owing to the absorbing action of the air upon them, have recently been photographed through a column of air two metres long. This refers to the extreme lines of zinc and aluminium.

The action of coloring matters upon the sensitiveness of plates has long been a subject of investigation by Mr. Schumann, to whom we are indebted for our best knowledge of the action of cyanine, which is shown on some of the plates exhibited.

The definition of lines even with nine prisms is extremely good, but the lines are very fine and delicate, not to be compared with those of Professor Rowland's large diffraction plates. On the other hand, the train of prisms gives more light than a grating of the same dispersion.

A METHOD OF MOUNTING PHOTOGRAPHIC PRINTS ON PAPER. By ROMYN HITCHCOCK, Washington, D. C.

[ABSTRACT.]

A METHOD of mounting photographic prints on thin paper without cockling has long been desired, in order that prints may be bound in a convenient form for reference. Cards are too bulky and heavy for large numbers of prints. After numerous experiments, the author succeeded in preparing a cement composed of shellac and mastic, which serves the purpose perfectly well. Prints may be mounted on paper, retaining their gloss and forming light and tasteful books.

SOME NOTES ON THE ESTIMATION OF NITROGEN BY THE KJELDAHL METHOD. By M. A. SCOVELL, Director Kentucky Agricultural Experiment Station, Lexington, Ky.

[ABSTRACT.]

1. Results obtained on C. P. Nitrates by the "Official Method."
2. By variations.

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INTERNATIONAL STANDARDS FOR THE ANALYSIS OF IRON AND STEEL. By Prof. JOHN W. LANGLEY, Pittsburg, Pa.

[ABSTRACT.]

A SYSTEM of International standards has been arranged for with England, France, Germany, Sweden, and for the United States.

A description of the system was given and the Section asked to name one chemist to act with six others to conduct the analyses on behalf of the American Committee on the International Standards, and to cooperate with European Analysts.

JADEITE AND NEPHRITE. By Dr. L. P. KINNICUTT, Worcester, Mass.

[This paper will be printed in full in the Proceedings of the American Antiquarian Society. Vol. VI, Part 1, 1889.]

THE RELATION BETWEEN EVAPORATIVE TESTS UNDER BOILERS AND PROXIMATE CHEMICAL ANALYSES OF COALS AS DETERMINED FROM NINETEEN SOUTHERN COALS. By Prof. OLIN H. LANDRETH, Vanderbilt Univ., Nashville, Tenn.

ON THE USE OF FLUORIAL COMPOUNDS IN SOFTENING HARD WATERS. By Dr. CHARLES A. DOREMUS, 92 Lexington Ave., New York, N. Y.

ON THE DETECTION OF MORPHIA IN URINE. By Dr. CHARLES A. DOREMUS, 92 Lexington Ave., New York, N. Y.

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Report of the Committee on Spelling and Pronunciation of Chemical Terms.

Your committee sent out, to American chemists, in May, 1889, a provisional list of words based upon the list compiled by Prof. J. H. Appleton, of Brown University, with a request for criticism. To this twenty-six replies were received, which were digested by the committee, and a report based upon these replies and upon careful study of the subject was presented to the Chemical Section at the Toronto meeting. It was voted by the Section that this report be printed and copies sent as far as practicable to all American chemists for criticism. The list presented in the original report has been revised and contains the recommendations as voted by the Chemical Section. Words thus voted on are designated by an asterisk. Spelling and pronunciation marked by a dagger were accepted by the Section without criticism.

It is extremely desirable that the next report of the committee should be thoroughly representative and therefore the coöperation of every American chemist is earnestly sought. It is hoped that every chemist will examine the list and plainly note *all* alterations in spelling and pronunciation which may seem to him desirable, and at the same time as far as it will not entail too much labor, give reasons for changes?

Replies are requested before March 1, 1890.

Thomas H. Norton, *Chairman*,
University of Cincinnati,

Edward Hart,
Lafayette College,

H. Carrington Bolton,
New York,

Jas. Lewis Howe,
Polytechnic Society, Louisville, Ky.,
Committee.

Please send replies to

Dr. Jas. Lewis Howe,
Polytechnic Society,
Louisville, Ky.

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GENERAL PRINCIPLES OF PRONUNCIATION.

1. The pronunciation should be as much in accord with the analogy of the English language as possible, yet continental pronunciation should be approached, inasmuch as it is used by a large proportion of the world's chemists, and by a continually increasing number of American chemists.

2. Present usage should be retained as far as possible.

3. Derivatives should keep as far as possible the accent and pronunciation of the root word, in order to make the original sense as clear as possible. This is subordinate to Rule 1.

4. Distinctly chemical compound words should retain the accent and pronunciation of each portion.

5. Similarly sounding endings for dissimilar compounds should be avoided, hence -în, -id, -ite, -āte.

6. Utility often determines usage even when contrary to analogy.

PREFIXES.

GENERAL RULE. All prefixes in strictly chemical words should be considered as parts of compound words, and hence should retain their own pronunciation, unchanged.

mō′no-	nī′tro- or nî′tro- (Hart: nī′tro-)	anhȳ′dro-
dī-		arsĕ′nio-
bī-	nītrō′so- or nîtrō′so-	xă′ntho-
trī-	ă′zo-	ī′so- (Howe: ĭ′so-)
tĕ′tra-, etc.	dīă′zo-	mĕ′thyl-
ă′cēto-	ă′zo-ă′mido	ĕ′thyl-
*ă′mīdo- (Bolton: amī′do-)	hȳ′dro-	prō′pyl-, etc.

NON-METALS, ETC.

hy′drogen	glȳ′cogen	sŭ′lphur
ō′xygen	ămī′dogen	phō′sphorus
nī′trogen	* chlō′rīn	ca′rbon
hă′logen	* brō′mīn	bō′ron
cȳă′nogen	* ī′odīn	sī′licon
dī″cya′nogen	* flū′orīn	†arsĕ′nicum
pă′racya′nogen		

Fāte, făt, făr, mēte, mĕt, pīne, pĭn, marîne, nōte, nŏt, mŏve, tūbe, tŭb, rüle, mȳ, ŷ = ĭ.

′ Primary accent; ″ secondary accent. N. B. The accent follows the vowel of the syllable upon which the stress falls, but does not indicate the division of the word into syllables.

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METALS.

Usage has determined the pronunciation except in a few instances.

ă'ntimony	ma'nganese (ez as in breeze.)	ku'pferni'ckel (koop)
bi'smuth (biz-)	me'rcury	sI'lver
cō'balt	ni'ckel	tŭ'ngsten
co'pper		zinc
I'ron		

Words in *-ium* have antepenultimate accent, and the vowel of this syllable is short if *i* or *y*, or if before two consonants, but long otherwise.

*alū'minum (Bolton & Howe: aluml'nium)	irI'dium	strō'ntium (shium)
	lI'thium	tellū'rium
ammō'nium	magnē'sium (zhium)	te'rbium
diĕ''thylammō'nium	niō'bium	thă'llium
bā'rium (Bolton: bă'rium)	ō'smium	thō'rium
	pallā 'dium	†tĭtā'nium
berў'llium	phosphō'nium	ūrā'nium
cad'mium	diĕ''thylphosphō'nium	vănā'dium
caē'sium	potă'ssium	ytte'rbium
ca'lcium	rhō'dium	ў'ttrium
cē'rium	ruthē'nium	zircō'nium
chrō'mium	samā'rium	lă'nthanum
†dIdў'mium	sca'ndium	†mōlў'bdenum
e'rbium	sĕlē'nium	plă'tinum
I'ndium	sō'dium	tă'ntalum

TERMINATIONS IN -IC.

Accent penultimate.

Penultimate vowel in polysyllabic words short, except (1) *u* when not before two consonants; and (2) when penultimate syllable ends in a vowel; in dissyllables long, except before two consonants.

alūmI'nic	†nI'ckelic (nI'ck'lic)	boră'cic
ammō'nic	platI'nic	bō'ric
argē'ntic	plŭ'mbic	brō'mic
bā'ric	strō'ntic	carbō'nic
bismū'thic	tĭtă'nic	dithiō'nic
coba'ltic (a as in ball)	ūră'nic	fē''rrocў̄ă'nic
mangă'nic		hydriō'dic
mercū'ric	arsē'nic	hy''drochlō'ric

Fāte, făt, fär, mēte, mĕt, pine, pĭn, marine, nōte, nŏt, mōve, tūbe, tŭb, rüle, mў, ў = ĭ.

' Primary accent; '' secondary accent. N. B. The accent follows the vowel of the syllable upon which the stress falls, but does not indicate the sion of the word into syllables.

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iō′dic	benzō′ic	phthă′lic (tă′lic)
mĕ″tantimō′nic	butў′ric	pi′cric
mĕ″taphosphō′ric	cacodў′lic	prŭ′ssic
mĕ″tastă′nnic	camphō′ric	†racĕ′mic or racē′mic
mōlў′bdic	carbă′mic	rosĕ′llic
phosphō′ric	carbō′lic	sacchă′ric
py″rophosphō′ric	carbō′nic	salicy′lic
sĕlĕ′nic	†chlō″racētic or chlō″racĕ′tic	sebă′cic
sili′cic	chrўsophă′nic	sūbĕ′ric
sŭ″lphocўă′nic	cinnă′mic	tărtă′ric
tellū′ric	ci′tric	†valĕ′ric or valē′ric
ablĕ′tic	cyanū′ric	succi′nic
†acē′tic or acĕ′tic	diălū′ric	alĕ′mbic
abieti′nic	fūmă′ric	allotrō′pic
absi′nthic	glycō′lic	aromă′tic
ăcĕ′ric	hippū′ric	atō′mic
ăcētō′nic	hўpogaē′ic	bā′sic
ăcētў′lic	ī″sobutў′ric	elĕ″ctrolў′tic
aconi′tic	mā′lic	īsomĕ′ric
acrў′lic	malō′nic	mō″nobā′sic
adi′pic	melli′tic	mō″nohў′dric
alcohō′lic	methy′lic	polymĕ′ric
aliză′ric	mū′cic	tĕtratō′mic
allў′lic	myrō′nic	tribā′sic
amygdă′lic	olē′ic	
amў′lic		

TERMINATIONS IN -OUS.

Words in *-ous*, following the general rule of the language, take antepenultimate accent, except when two consonants follow the penultimate vowel, in which case the accent is thrown forward.

(A clear distinction is thus made in accent as well as in termination between words in *-ic* and *-ous*.)

†acē′tous (exception through usage)	sĕlē′nious	plă′tinous
arsē′nious	sŭ′lphūrous	ti′tanous
chlō′rous	tĕ′llūrous	alliă′ceous
hy″drosŭ′lphūrous	bi′smūthous	alumeni′ferous
hy″pochlō′rous	chrō′mous	amўlă′ceous
hy″ponī′trous	cō′baltous	auri′ferous
hy″pophō′sphōrous	mă′nganous	gă′seous (gazeous)
hy″posŭ′lphūrous	mĕ′rcūrous	gela′tinous
phō′sphōrous	ni′ckelous	pyroli′gneous

Fāte, făt, fār, mēte, mĕt, pīne, pĭn, marine, nōte, nŏt, mōve, tūbe, tŭb, rüle, mў, ў = i.

′Primary accent; ″secondary accent. N. B. The accent follows the vowel of the syllable upon which the stress falls, but does not indicate the division of the word into syllables.

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TERMINATIONS IN -ATE.

Antepenultimate accent (occasionally thrown back).

ă′bĭētāte	alĭ′zarāte	cȳ′ănāte
ă′cerāte	ammō′nĭāte	fū′lmināte
ă′cētāte	amў′gdalāte	glȳ′cŏllāte
ă′cetonāte	ă′mylāte	vă′nadāte
ă′dipāte	antimō′nĭāte	†tĭ′trāte
ă′lcoholāte	ă′rsenāte	

TERMINATIONS IN -ITE.

Accent analogous to *-ate* terminations.

ă′cetĭte	ă′rsenĭte	mă′nnĭte
ă′ntimonĭte	hy″pophō′sphĭte	

TERMINATIONS IN -IDE AND -ID.

* Drop final e in every case, and pronounce *-id* (see note 1). Antepenultimate accent.

ă″cētă′nilĭd	cȳă′melĭd	ă′lkală′mĭd
hȳ′drĭd	glū′cosĭd	bĕ′nzylă′mĭd
anhȳ′drĭd	hy″drosŭlphĭd	că′rbă″mĭd
ă′nilĭd	ŏ′xĭd	cȳă′nă″mĭd
brō′mĭd	hȳdrō′xĭd	dĭ′ă′cētă′mĭd
chlō′rĭd	murĕ′xĭd	dĭcyă′nă″mĭd
flū′orĭd	ŏ″xychlō′rĭd	lă′ctă″mĭd
ĭ′odĭd	ă′mĭd	ŏ′xă″mĭd
cȳ′ănĭd	ă′cētă′mĭd	

TERMINATIONS IN -ANE.

Hydrocarbons belonging to the *-ane*, *-ene*, and *-ine* groups of Hofmann take long vowel.

mĕ′thāne	hĕ′ptāne	ĭ″sobū′tāne
ĕ′thāne	ŏ′ctāne	ĭ″sopĕ′ntāne
hĕ′xāne		

TERMINATIONS IN -ENE.

Antepenultimate accent. Some dissyllables, as benzene, have no distinct accent.

ă″cēnă′phthēne	ăcĕ′tylēne	ă′mylēne
ă′cētnă′phthylēne	ă′llylēne	†ă′nthracēne

Fāte, făt, fär, mēte, mĕt, pīne, pĭn, marĭne, nōte, nŏt, mōve, tūbe, tŭb, rūle, mў, ў = ĭ.

′ Primary accent; ″ secondary accent. N. B. The accent follows the vowel of the syllable upon which the stress falls, but does not indicate the division of the word into syllables.

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ă′sphăltēne
ă″zobĕ′nzēne
bĕnzēne
bĕ′nzylēne
bū′tylēne
caprў′lidēne
cētēne
crotŏ′nylēne
decē′nylēne
diă′mylēne
dībrōmbĕnzēne
ĕ′thidēne
ĕ′thylēne
hĕ′ptylēne
ĭ″sobū′tylēne
ĭ″sohĕ′ptylēne
mesĭ′tylēne
mĕ″taxy′lēne
mē′thylēne
nă′phthalēne
oēnanthў′lidēne
pē′ntylēne
phenă′nthrēne
terabĕ′nthēne
tŏ′lūēne
valĕ′rylēne
xў′lēne
glū′tĕn
*albū′men

TERMINATIONS IN -INE.

Doubly unsaturated compounds in *-ine* take the normal pronunciation *-īne*.

ĕ′thine
prō′pine

TERMINATIONS IN -IN.

*All chemical compounds now ending in *-in* and *-ine* (except doubly unsaturated compounds, considered above) should end in *-in*, and this syllable should be pronounced *-in* (see note 2).

The accent is antepenultimate, except when the penultimate vowel is followed by two consonants, in which case the accent is penultimate.

chlō′rin
brō′min
ĭ′ōdin
flū′ŏrin
ă′min
mĕ′thylă′min
ĕ′thylă′min
ă″cēdiă′min
ă′cetonă′min
phŏ′sphin
ă′rsin
ă′conin
acō′nitin
ă′mmelin
ă″nthrapu′rpurin
ă′sbolin
ă′nilin
aspă′ragin
ă′tropin
bĕ′nzin
brū′cin
chō′lin
chў′soidin(oi as in soil)
cinchŏ′ninc in
cĭ′nchōnin
cō′nin
crĕă′tinin
crē′atin
cū′rarin
guă′nidin (gwă)
guă′nin (gwă)
hў′drazin
hyoscў′amin
mo′rphin
ō′lĕfin
quĭ′nicin
quĭ′nidin
quĭ′nin
rōsă′nilin
stry′chnin
tolū′idin
vă′sēlin
ă′bietin
absi′nthin
ă′cetin
alĭ′zarin
alloxă′ntin
ă′lylin
amў′gdalin
ă′mylin
au′rin
conĭ′ferin
cū′marin
dĕ′xtrin

Fāte, făt, fār, mēte, mĕt, pīne, pĭn, marîne, nōte, nŏt, mōve, tūbe, tŭb, rüle, mў, ў = ĭ.

′Primary accent; ″secondary accent. N. B. The accent follows the vowel of the syllable upon which the stress falls, but does not indicate the division of the word into syllables.

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dichlōrhȳ′drĭn
dĭĕ′thylĭn
dĭstē′arĭn
emŭ′lsĭn
fĭ′brĭn
flūorĕ′scĭn
gĕ′latĭn
glŏ′bŭlĭn
glĭ′adĭn
glū′tĭn
gly′cerĭn (gly′cerōl preferred)
†hĕ′moglō′bĭn
†hĕ′matĭn
†ĭ′ndĭgotĭn
ĭ′nulĭn
ĭ′satĭn
leū′cĭn
mō″nostē′arĭn
mȳ′osĭn
nä′rcotĭn
neū′rĭn
nĭ′cotĭn
pă′lmitĭn
păpă′verĭn
pĕ′psĭn
plpĕ′ridĭn
pu′rpurĭn
reso′rcĭn
să′licĭn
sa′rcĭn
stē′arĭn
sy′ntōnĭn
tă′nnĭn
*vă′nĭllĭn

(*In following nine words, penultimate accent obscure.*)

thē′baĭn
†cō′caĭn
acrō′leĭn
că′ffeĭn
cō′deĭn
cā′seĭn
flūorĕ′sceĭn
nä′rceĭn
cōnĭ′ĭn
*thē′ĭn (tēĭn) (Hart: word should be dropped).
allă′ntōĭn
†bĕnzōĭn
ă′lkaline
cry′stallĭn or cry′stalline.

TERMINATIONS IN -ONE AND -ON.

*albū′mĭnōne
ă″nthraquĭnōne
quĭnōne
kētōne
ă′cētōne
bō′rŏn
cä′rbŏn
hȳ″drōcă′rbŏn
collō′dĭŏn
sĭ′lĭcŏn

TERMINATIONS IN -AL, -IL, -OL, -YL, -YDE, ETC.

ă′cetăl
bĕ′nzăl
cblō′răl
nī′trĭl
ă′cētonĭ′trĭl

-ol, final *e* dropped; *-ōl*, with two exceptions from usage.

ă′lcohŏl
ă′nĕthōl
ä′rgōl
be′nzōl (undesirable, should be dropped.)
crē′sōl
glȳ′cerōl
†glȳ′cōl
ĭ′ndōl
†nă′phthōl
*phĕ′nōl
*thȳ′mōl (tī)

-yl, antepenultimate accent.

ăcĕ′tonȳl
†ăcētȳl
ăllȳl
ă′mȳl
bĭ′smūthȳl
·bō″rĕ′thȳl
bū′tȳl
că′codȳl
cä′rbonȳl

Fāte, făt, fär, mēte, mĕt, pine, pĭn, marĭne, nōte, nŏt, mōve, tūbe, tŭb, rūle, mȳ, ȳ = ĭ.

′Primary accent; ″secondary accent. N. B. The accent follows the vowel of the syllable upon which the stress falls, but does not indicate the division of the word into syllables.

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†cărbŏ′xȳl	dīphĕ′nȳl	lă′ctȳl
cē′rotȳl	dīprō′pȳl	mĕ′thȳl
cē′tȳl	fo′rmȳl	†nītrŏ′xȳl
chrō′mȳl	hĕ′ptȳl	nī′trȳl
diă′llȳl	†hydrŏ′xȳl	ŏ′ctȳl
diă′mȳl	ī″sobū′tȳl	†phĕ′nȳl
dimĕ′thȳl	ī″soprō′pȳl	prō′pēnȳl

-yde, antepenultimate accent.

†ă′ldehȳde	bĕ″nză′ldehȳde	pā″ră′ldehȳde
ă′cētă′ldehȳde.	mĕ″tă′ldehȳde	

-METER.

† Words ending in the termination *-meter* take the normal antepenultimate accent (from usage); except that the words of this class used in the metric system are considered as compound words, and each portion retains its own accent.

ăcētī′meter	micrŏ′meter(instrument)	dĕ′cimē″ter
ăcētō′meter	ureŏ′meter	hē′ctomē″ter
ăcidī′meter	urinŏ′meter	kī′lomē″ter
alcholō′meter		mȳ′riamē″ter
alkalī′meter	mī′llimē″ter	mī′cromē″ter (measure)
bārō′meter	cē′ntimē″ter	
eudiō′meter	dĕ′kamē″ter	

MISCELLANEOUS.

brō′moform	ăcētī′metry	bī′vā″lent
chlō′roform	ăcidī′metry	trī′vā″lent.
iō′doform	alcoholō′metry	† qua′drivā″lent
ă′mylōse	alkalī′metry [in boil.]	qui′ntivā″lent
cĕ′llulōse	† stoichiŏ′metry (oi as	atomi′city
dĕ′xtrōse	alcoholomĕ′tric	basi′city
glū′cōse	baromĕ′tric	mō′nad
lă′ctōse.	acētificā′tion	tē′trad
†lĕ′vūlōse	cupellā′tion	†ă′llotrŏpy
ma′ltōse (a as in ball)	distillā′tion	† ă′llotrŏpism
sū′crōse	ebulli′tion	† ī′somerism
sy′năptāse	fermentā′tion	† pŏ′lymerism
ă′lkaloid	lixiviā′tion	ană′lysis
ă′lmyloid } oi as	† titrā′tion	atmŏ′lysis
cŏ′lloid } in	vā′lence	diă′lysis
cr′ystalloid } boil.	qua′ntivā″lence	electrŏ′lysis
* albū′minoid	mō′novā″lent	acĕ′tify

Fāte, făt, fär, mēte, mĕt, pīne, pĭn, marīne, nōte, nŏt, mŏve, tūbe, tŭb, rūle, mȳ, ȳ = ī.

′ Primary accent; ″ secondary accent. N. B. The accent follows the vowel of the syllable upon which the stress falls, but does not indicate the division of the word into syllables.

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acĭ′dify	† grăm (so derivatives)	† bărȳ′ta
ā′erate	† lĭter	bō′rax
āē′riform	† tĭter (to be avoided)	că′ramel
† alloy′ (noun)	†tĭ′trāte	lĭ′tharge
† alloy′ (verb)	† tĭtrā′tion	† ōlē′fiant
amă′lgam	ammō′nia	salt pe′ter
amă″lgamā′tor	ammō′niac	ve′rdigris
* apparā′tus	ammōnī′ăcăl	ăcĭ′cular
*apparā′tus (plural)	* ă′ntimonetted	ă′lchĕmist
† a′ssay (noun)	* ă′rsenetted	ă′node
† assay′ (verb)	că′rburetted	ăqua fo′rtis
† assay′er	te′llūretted	ăqua rē′gia (re-gi-a)
* cŏ′ncentrated	sŭ′lphūretted	cĕ′ntigrade
dĕ′flagrating	phŏ′sphoretted	crystallō′graphy
dilū′te	ă′dipocere	fū′marole
* mō′lecule	ă′lkali	găngue
* mōlĕ′cular	ă′lkanet	me′tallu″rgy
fe′rment (noun)	†allŏ′xan	* nō′mĕnclā″ture
ferme′nt (verb)	ă′ntichlor	* ra′dical
na′scent	† asbe′stos	speiss (spice)
† mē′ter	ă′sphălt	tū′bulature

Fāte, făt, fär, mēte, mĕt, pine, pĭn, marîne, nōte, nŏt, mōve, tūbe, tŭb, rūle, mȳ, ў = i.

′ Primary accent; ″ secondary accent. N. B. The accent follows the vowel of the syllable upon which the stress falls, but does not indicate the division of the word into syllaples.

NOTE 1. *-id.* This pronunciation distinguishes clearly between *-id* and *-ite.* In German it is difficult and often impossible to distinguish between *-id* and *-it*, and in English a confusion often arises between chlorite and chloride, sulphite and sulphide, etc.

See also the following note.

NOTE 2. *-in.* The final e in these words should be dropped as of no important significance.

I. The suggestion of Watts and others to indicate basic substances by *-ine* and all others (or neutral substances) by *-in* seems unwise. It makes a difference in spelling, with little or no corresponding difference in pronunciation on the part of most chemists,— a useless and undesirable complication. It demands a very extensive knowledge of the constitution of a great number of compounds with these terminations. It has been partially adopted by many chemists but not consistently by most, and by many it has never been recognized.

II. All continental languages use the pronunciation *-in* and this is the case with not a few words in English as benzine, marine, while the American public have instinctively taken up this pronunciation in "Pearline, Soapine," etc. In general however it seems too foreign to English usage to be adopted by a majority of American chemists.

-ine is awkward and would be very foreign to English usage in many words, as chlorine, morphine, nicotine, brucine, etc., etc.

The pronunciation *-in* is already common in many of these words, as the halogens, anilin, hematin, pepsin, tannin, etc., and at the same time presents a near approach to the continental *in*, into which it may easily be strengthened if preferred.

The above note applies equally to the termination *-id.*

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SECTION D.

MECHANICAL SCIENCE

AND

ENGINEERING.

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Members of Sub-committee on Nominations.

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PAPERS READ.

ON THE RELATIVE PERFORMANCE OF MODERN AIR COMPRESSORS. By Prof. J. E. DENTON, Stevens Institute, Hoboken, N. J.

[ABSTRACT.]

RESULTS of measurements of the power expended in compressing air to high pressures are given by means of data from indicator cards collected from most of the makes of air-compressing machines used for tunnelling operations in Europe and America. It is shown that all attempts to maintain the temperature of air uniform, during compression by the injection of water, either in the form of spray or *en masse*, fail to cause the compression curve to become coincident with an isothermal or Mariotte line. The curve of compression actually realized by the use of water in the most effective manner coincides with an hyperbola whose form is represented by the equation $p\ v^{1.22} = \text{constant}$, p being the absolute pressure and v the volume of the air compressed. This is equivalent to the statement that if the saving in power expended to compress air along an isothermal as compared to compressing it along an adiabatic be represented by unity, the saving actually realizable by any cooling with water is only about one-half. It appears that even when the temperature of the compressed air is maintained at less than 100° Fahr. at exit from the compressing cylinder, the power saved is no greater than the above amount.

The general conclusion drawn is that the cooling of the air is accomplished mainly during the ejection of the air from the compressor *after the compression is completed.*

It is also shown that water Jacketed compressors realize the economy of water injection compressors so nearly, that in view of the injurious effects of water in the cylinders, the Jacket system is the most economical commercially.

ON THE CYLINDER CONDENSATION OF MULTIPLE EXPANSION ENGINES. By Prof. J. E. DENTON, Stevens Institute, Hoboken, N. J.

[ABSTRACT.]

ATTENTION is called to the fact that the most recent reliable experiments with engines indicate that the steam unaccounted for by the indicator is approximately proportional to the product of the time of admission and the

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range of temperature due expansion in the cylinder taking steam directly from the boiler and the surface to which steam is exposed at the instant of cut-off in this cylinder. It follows that the percentage of steam unaccounted for by indicator in the case of multiple expansion engines is not greater and may be less than for single cylinder engines having equal ratios of expansion and equal power.

RESISTANCE OF AIR TO INCLINED PLANES IN MOTION. By O. CHANUTE, 5 Ritchie Place, Chicago, Ill.

[ABSTRACT.]

PÉNAUD stated in 1876, that the laws of fluid pressures as laid down by Newton did not agree with experiments with inclined planes, and T. W. Mather, in an article in the Popular Science Monthly in 1885, stated that mathematicians were yet unable to accurately calculate the sustaining reactions and resistances which birds meet with in their flights. There are also serious anomalies in the calculated wind effects on bridges and roofs as compared with actual disasters.

The author recently conceived a new theory on the subject, and being in Europe, he presented it briefly before the International Congress of Aeronautics at Paris, where it was received with such favor, that although it is still crude and undeveloped, he believes it is worth presenting to the American Association for the Advancement of Science for criticism and discussion.

The theory is based upon two generally accepted laws:

1. That fluid pressures are in direct proportion to the number of molecules affected by the motion. 2. That the pressure of a fluid jet in front of a plane is correctly given by Rankine's formula $F = \frac{d A \Delta^2}{g}$ in which the height of the pressing column is assumed to be double that producing the velocity.

The author suggests that there is no warrant for assuming that the geometrical figure enclosing the molecules is that of a column, but that it may be a prismoid, with flaring sides, with only the height due to the velocity, and still enclose double the number of molecules of a parallelopipedon of equal altitude.

He believes that when air is compressed, the molecules press not only upon the plane, but also sidewise upon those outside of the direct line of current, so that the cleavage of the air, so to speak, flares out at angle from the plane. He believes that a further action takes place behind the plane in consequence of the partial vacuum produced by the current rushing by.

The author believes that further experiments (which he indicates) are required to work out general formulæ, but he gives some approximate for-

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mulæ, and five tables, showing how the results of experiment disagree with the old theory, and seem to agree closely with the new. He also states some of the consequences of the new theory, as to various phenomena of wind pressures.

He applies the formulæ to the measure of the sustaining reactions and resistance of the air to a soaring pigeon, and shows that at twenty-five miles per hour, an angle of 1° with the horizon is sufficient to produce a pressure which will sustain the weight of the bird, while the work done is at the rate of 10½ horse power per ton of weight, or about one-third that hitherto required for navigable balloons.

PRESERVING WOOD AGAINST DECAY. By O. CHANUTE, 5 Ritchie Place, Chicago, Illinois.

[ABSTRACT.]

THE growing scarcity of wood in this country is forcing upon our attention economical means of lengthening its resistance to decay.

The Europeans have been compelled by the same reason to experiment largely with various chemicals, and during the last forty years have achieved such success that a railway manager is now not considered a prudent manager, if he fails to avail of some of them.

At least four methods have proved a success; they are:

(1) Kyanizing, or preserving with corrosive sublimate.
(2) Cupperizing " " " sulphate of copper.
(3) Burnettizing " " " chloride of zinc.
(4) Creosoting " " " dead oil of coal tar.

The first two methods are gradually losing ground, but the last two are now largely employed. Of these creosoting is the most effective, but also the most costly, and in view of the yet smaller price of timber in this country, it would seem to the author that the best process for us to use at present is that of burnettizing, particularly for railway ties which are destroyed in part by the mechanical action of the foot of the rail cutting into them, in addition to the operation of decay.

In applying either of the above methods, great care is to be observed to have the work well done, the wood well prepared for absorbing the solutions, and the latter to be of good quality, neither too weak nor too strong. Until the working of the processes are thoroughly understood, it will be best to have them supervised by experts.

The selection of the kinds of wood to be treated is also quite important. Close grained timber such as white oak or chestnut should not at present be treated at all. It is better to use it unprepared, but the more porous woods, such as hemlock, bastard pine and beech will take the treatment well, and the life of wood will be at least doubled thereby.

Reference is made to the report of a special committee of the American Society of Civil Engineers in 1885, for further details and records of experiments.

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NOTE ON THE PERFORMANCE OF A VIBRATING PISTON ENGINE. By Prof. M. E. COOLEY, Ann Arbor, Mich.

[ABSTRACT.]

THE following results were obtained from a test on an 8 to 10 H. P. Kimble engine, manufactured by the Kimble Engine Co., Kalamazoo, Mich. The piston is 4½ inches wide and 6 inches long and attached to a 2-inch shaft at the middle of its length; the ends of this shaft by means of arms, wrist-pins, and connecting rods, connect with the cranks on the main shaft. Steam is admitted through ports at the extremities of the arc of the circle of the top of the cylinder by means of a rocking valve operated by an excentric on the main shaft controlled by an automatic governor.

The engine when tested was new, never having had steam on it before, and was not run more than ten minutes before the friction test was begun. The friction under loads varying from 2.39 I H. P. to 13.37 I H. P. averaged 22.6 per cent, and was nearly constant.

With a boiler pressure of 81.4 lbs. and a cut-off at about ⅓ stroke at 375 revolutions per minute the consumption of dry steam per I H. P. per hour averaged 41.32 lbs. (calorimeter tests showed the steam to contain only 2 06 per cent. moisture). The back pressure was so high, owing to a faulty valve, that the horse power was measured down to the atmospheric line for purposes of comparison.

Average total horse power	12.237
" net " "	10.121
" lost " " (due to back pressure)	2.046

Steam per total horse power per hour = 34.41 lbs.

Considering the size of the engine, the fact that it was perfectly new, and also that the steam connections were not as direct as they should have been, the results as stated may be considered quite equal to those obtained from reciprocating engines under similar conditions.

NOTE ON THE FRICTION OF WATER IN PUMP PASSAGES. By Prof. M. E. COOLEY, Ann Arbor, Mich.

[ABSTRACT.]

A TEST for duty made on a compound duplex pumping engine developed the following results:

Dimensions of pumps. Diameter of H. P. cylinder, 14 inches; L. P. cylinder, 26 inches; water plunger, 14 inches; stroke, 18 inches; daily capacity, 2,000,000 gallons; diameter suction, 14 inches; diameter force main, 12 inches; length force main, about 4000 feet; height of discharge above centre of plungers, 198.5 feet.

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Performance of pumps.—

Average steam pressure in boiler (by gauge), . . .	76.2 lbs.
" vacuum in condenser, ...	21 92 ins.
" total pressure in force main, ...	99.35 lbs.
" suction in suction pipe, ...	11.28 ins.
" total head pumped against in feet of water, . .	244.6

All of the preceding results were secured by using sensitive gauges, standardized. The pressure in the force main was taken on a level with centre line of plungers, and the suction, from the head of the suction pipe and at the same level.

The following results were secured by using indicators having short 1-inch connections with the water cylinders.

Average mean effective pressure in the water cylinders, . . 114 lbs.
Equivalent head in feet of water, ... 265
Difference of head as measured outside and inside the cylinders, 20.4 ft.

$\frac{265 - 244.6}{244.6} = \frac{20.4}{244.6} = 0.0834$, or the duty as measured in the pump cylinders is 8.34 per cent. greater than that in the mains just outside the pumps.

The following partial heads go to make up the total head:

Height of discharge above centre of plungers, . .	198.5 feet.
" " suction to " " " . . .	12 8 "
" due to friction in force main (computed) . .	22.4 "
" " " " of elbows, valves and other obstructions in force main, etc., ...	10.9
Friction of valve and other passages in pump, . .	20.4
Total, ...	265.

Four six-inch rubber disc valves were used in each end of water cylinders, held down by coil springs. The suction was common to both cylinders, and the discharge pipes from the pumps abut directly against each other, the force main branching out from these pipes at a sharp right angle, the air chamber being placed on top at the common point of meeting.

The average piston speed under which the preceding results were obtained was about 97 feet per minute; at higher speeds the friction became much greater.

NOTES ON ANTI-FRICTION CONSTRUCTION FOR THE REVOLVING MECHANISM FOR OBSERVATORY DOMES. By W. R. WARNER, of Cleveland, Ohio.

[ABSTRACT.]

IN the construction of the observatory domes for the University of Virginia, Johns Hopkins University, Smith College and many others, the sliding friction has been entirely eliminated, and therefore no lubrication is required or provided for.

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The line ring is jointed and flexible and the conical wheels have no flanges.

The wall plate forming the tracks is accurately turned to the proper cone so that when the conical wheels are in position their top surfaces are level, and therefore the track on the sole plate or base ring of dome is a plane instead of a cone. The dome is held in lateral position by guide wheels carried by armatures reaching from the base ring of the dome to the wall plate.

The axes of each conical wheel are held in a light cast iron yoke by ball bearings the same as are used in bicycles. These axes, however, sustain no weight except that of the light yoke and are only used to keep the axis a true radius of the circle of the dome. This is accomplished by two light lateral wheels attached to each yoke, these wheels having the same kind of ball bearings above mentioned. It will thus be seen that the conical wheels require no flanges, and that there is no place for sliding friction, all possible resistance being reduced to rolling friction.

The flexible line ring allows the walls of the observatory to change their shape without increasing the power required to revolve the dome, while the guide wheels attached to each yoke carrying the conical wheels keep the axis of each conical wheel a true radius of the part of the circle on which it is running.

The tests given these domes show that a direct pressure of 1¼ lbs. per ton is sufficient to revolve them and after five years of use and exposure they turn just as easily as when first erected.

STEAM INJECTORS. By ERNEST B. PERRY, Industrial Works, Bay City, Mich.

ON A DIAGRAMMING APPARATUS FOR USE IN THE TESTING OF MATERIALS. By Dr. THOMAS GRAY, Terre Haute, Ind.

ACHIEVEMENTS OF THE SHARPNECK ROLLER-BEARING JOINAL BOX. By CHAS. D. WALCOTT, U. S. Geological Survey, Washington, D. C.

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SECTION E.

GEOLOGY AND GEOGRAPHY.

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ADDRESS

BY

PROFESSOR CHARLES A. WHITE,

VICE PRESIDENT, SECTION E.

THE NORTH AMERICAN MESOZOIC.

It has become customary upon such occasions as this for the speaker to select a theme from subjects which he is supposed to have specially studied; and I have therefore chosen for mine the Mesozoic division of the geological record as it is exhibited on this continent. This theme is so comprehensive that I propose only to select from it certain topics which pertain to the distinguishing characteristics of the principal subdivisions of the Mesozoic that have been recognized in different portions of North America; to their interdelimitation and to the delimitation of the division as a whole from the Carboniferous system beneath, and the Cenozoic above. I shall also make the discussion of these topics the opportunity of expressing certain views which I hold concerning them.

To bring these discussions within the time allotted me they must be confined to three general sections of the Mesozoic formations, one of which occurs within each of three regions of the continent, namely, the Atlantic Coast, the Pacific Coast, and the Interior regions. Proceeding upon this plan let us first consider the general section which is to be observed in the Atlantic Coast region.

The rocks which in this region are now generally regarded as of Triassic age are found occupying limited isolated districts from Prince Edward Island on the north to the state of South Carolina on the south. If they extend further to the south, or southwestward, they are covered from view by later formations. They are found to rest unconformably upon various formations from the Archæan to the

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Carboniferous inclusive; except perhaps in Prince Edward Island, where they are reported as resting conformably, or nearly so, upon reputed Permian strata. Still, no intimate stratigraphical or paleontological connection between the Permian and the Trias has been shown to exist there; and the hiatus between them is doubtless as great as it is farther southward, where the unconformity is so conspicuous.

In this latter portion of the region it is evident that the great uplift which involved the paleozoic rocks, including the reputed Permian, took place long before the deposition of the earliest of those Triassic beds. These stratigraphical conditions indicate that the hiatus in the geological record between the latest of the Carboniferous, and the earliest of the Triassic deposits is equal to at least the earlier half of the Triassic, as that period is represented in Europe.

The only known paleontological evidence which appears to bear upon this subject agrees with the stratigraphical indications just mentioned. That is, the results of investigations by Professor Newberry upon the fishes and plants of the strata in question, and of Professor Fontaine upon the plants of the same, indicate that they represent the later Trias of Europe. But if Triassic fishes had not survived to the present day; and if we knew more concerning the developmental stages in the vegetable kingdom from the later Paleozoic to the later Mesozoic inclusive, a good degree of uncertainty which is naturally felt upon this point would doubtless disappear.

Our knowledge of the land vertebrate fauna which existed at the time these deposits were formed is derived mainly from footprints; and it is therefore more than usually imperfect. The character of this evidence as indicating Triassic, rather than earlier Jurassic age, seems to be far from unquestionable.

Very few invertebrate fossils have been found in the Trias of the Atlantic Coast region; and the few that have been discovered are of little or no value as indicating the age of the strata containing them.

As to the relation of these deposits with the Carboniferous system, only stratigraphical evidence has thus far been obtained, and this shows only the bare fact that the former are of considerably later age than the latter. That is, no direct, or even approximately close, biological relationship between them has yet been discovered, the biological hiatus being apparently quite as great as the strati-

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graphical one. It may be mentioned here also that we have no evidence that the Trias of the Atlantic Coast was ever continuous, or that it was exactly contemporaneous, with the reputed Trias of the Interior region, which will be presently referred to.

Intermediate between the Triassic beds and the undisputed Cretaceous deposits of the Atlantic Coast region there is a series of strata, evidently of littoral and estuary origin, but, at least, in part, of doubtful age, to which the name of Potomac formation has been applied. These deposits reach at most only a few hundred feet in thickness, and although frequently covered from sight by later formations, they seem to have been originally continuous from New Jersey to the state of Mississippi. They have no known representative west of the Mississippi river, unless it shall be shown that they are represented by some sandy beds at the base of the Texas Cretaceous section. These Potomac beds are usually found resting directly upon the Archæan, and at only a few points are they found to rest directly upon the Triassic rocks, when they are plainly unconformable. They seem to be constantly present beneath the marine Cretaceous strata just mentioned and no representative of another formation has yet been observed between them.

Invertebrate fossils are exceedingly rare in the Potomac formation, and the few that have been found give no direct indication of its geological age. Professor Whitfield, however, has suggested that the Raritan Clays, together with the Amboy Clays, which by some geologists are included in the Potomac formation, but which are probably of later date, are of Jurassic age because of the similarity of his new lamellibranchiate genus Ambonicardia, with certain European Jurassic shells.

Large collections of fossil plants have been obtained from the deposits here provisionally grouped together under the name of Potomac formation, at numerous and widely separated localities. These collections differ so greatly in character from one another that it seems necessary to infer that more than one flora is represented by them. Many years ago Dr. Tyson found some fossil plants in Maryland which he regarded as of Jurassic age, and which closely resemble certain forms that are found in the European Jura. Professor Ward, in reviewing the large flora which Professor Fontaine has published from the Potomac formation in Virginia, and having in mind also the Maryland plants just referred to, recognizes the Jurassic character of several of the species, according to the Euro-

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pean standard, but he takes the rational ground that all obtainable evidence ought to be considered before reaching a final decision as to the true age of the deposits containing them.

Professor Newberry, who has made extensive studies of the plant remains of the Raritan and Amboy clays, finds among them none that give any indication of their Jurassic age. On the contrary, he finds that the flora of those clays as a whole indicates that they ought to be referred to an epoch not later than the Middle Cretaceous of Europe, nor probably earlier than the upper Neocomian.

Professor Marsh has published some dinosaurian remains from apparently the same horizon in the Potomac formation that furnished the plants to Dr. Tyson and Professor Fontaine, which he has referred to the Jurassic.

Paleontological testimony being thus conflicting in its character, one naturally infers that more than one epoch is represented by the deposits that now bear the common name of Potomac formation; but I shall presently call your attention to some cases of commingling of earlier and later molluscan types in one and the same formation which are quite as remarkable as this apparent commingling of diverse plant and vertebrate types in the Potomac formation.

The marine Upper Cretaceous deposits of the Atlantic Coast region which immediately overlie the Potomac formation are best developed in New Jersey; but there is good reason to believe that they were originally continuous with contemporaneous deposits through the whole length of the region from Long Island to the Gulf states and thence westward to, and far northward within, the Interior region. This opinion is based upon specific identity of marine fossils discovered in the different regions.

The Upper Cretaceous of this region is overlain by Eocene deposits, also marine, with little if any observable unconformity where they have been found in contact. I shall, however, presently mention facts which indicate that there is in the Atlantic and Gulf Coast region a considerable hiatus between the Cretaceous and Eocene.

Briefly, then, the Mesozoic of the Atlantic Coast region consists of a probable representation of the Upper Trias of Europe, a possible one of the Upper Jura, a probable slight one of the Middle Cretaceous, and a practically certain representation of a large part of the Upper Cretaceous, but with an hiatus between the latter and the Eocene.

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Although the Cretaceous rocks are, or were originally, continuous between the Atlantic coast and interior regions by way of the Gulf states, the earlier Mesozoic rocks of those regions respectively are so widely separated from each other that, as we go westward, we do not find any that can be confidently referred to either the Trias or the Jura until we have passed the 100th or perhaps the 103d meridian.

As the latter meridian coincides with the western boundary of Texas, the foregoing statement implies that no Triassic rocks exist within at least the greater part of the fully thirty thousand square miles in that state and the Indian Territory, which some geologists have represented as being occupied only by rocks of that age. A personal examination of a large part of that region and of the fossils collected there, has satisfied me that the sum of all the known evidence is in favor of the Permian age of the strata in question and against their Triassic age. But these strata have an important paleontological relation with the Mesozoic, to which I wish to call your attention for a few moments.

Upwards of fifty species of vertebrates, embracing reptiles, batrachians and fishes, have been described from these rocks by Professor Cope, upon the evidence of which he referred them to the Permian of Europe, although, as he states, not one of the genera is common to both continents.

I have collected upward of thirty species of invertebrates from the same beds which furnished the vertebrates, representative examples of all the more important of which were obtained from one and the same stratum. Of these, fully one-half are common, characteristic Coal-measure species. A part of the cephalopod species, however, possess such decided Mesozoic characteristics that probably no special student of that class of fossil mollusca would hesitate to refer them to a formation not older than the Trias, if they had been submitted to him without any information as to their true stratigraphical position.

It is a significant fact that if three special selections were made from the fossils of all kinds that have been obtained from this formation in Texas, one could be made, by the usual method of chronological classification practised by paleontologists, to prove its Coal-measure age, another its Permian age, and still another its Triassic age. It is admitted that the sagacity of an experienced paleontologist will often enable him upon limited evidence to be-

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come satisfied in his own mind as to the approximate age of a given formation; but it is only after all the obtainable paleontological and stratigraphical facts are carefully considered together that one is justified in expressing a definite opinion upon a subject of this kind. Such a summing up of all the evidence at present available seems to fully justify the reference of this Texan formation to the Permian of Europe.

My special object in presenting the foregoing facts is to call your attention to the important paleontological relation of the Texan Permian with the Mesozoic, which is shown by the presence of Ammonitic and Ceratitic cephalopods among Paleozoic types of mollusks. The discovery of such forms in such association in the Texan Permian, as well as in the Productus limestone of India, shows conclusively that certain Mesozoic types began their existence long before the close of Paleozoic time. Such forms in such association may be properly regarded as harbingers of an approaching, but not yet established, Mesozoic era, because, in this case at least, the balance of paleontological evidence favors their reference to the Paleozoic. Such facts as those which have been mentioned, as well as others presently to be referred to, indicate that upon the confines of epochs, periods and ages of geological time there was always a commingling of types of then living forms which in their culmination were characteristic of each of those chronological divisions respectively. Furthermore, I shall call your attention to evidence that some of the types which especially characterized certain geological periods survived in full vigor through later periods. But let us return to a consideration of the Mesozoic rocks.

Those rocks of the great Interior region which have by common consent, but upon comparatively slight evidence, been referred to the Trias, are found upturned against the flanks of the Rocky Mountain, and other ranges, and exposed to view in the valleys and cañons of the Plateau province. They reach several thousand feet in thickness, and are so nearly uniform in color and lithological character over the whole of the great area within which they occur that they are often designated as the "Red Beds." They are found resting upon rocks of different age in different places, but in some districts they rest with apparent conformity upon a series of sandstone strata which are probably of Permian age.

This formation is apparently of non-marine origin and, as a rule,

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it is quite barren of fossils. The few molluscan remains that have been obtained from it give no indication as to its age and, in the light of present knowledge, the few plant and vertebrate remains obtained from it are far from satisfactory in this respect. Still, it is not my object to deny the Triassic age of this formation, but only to call your attention to the fact that paleontological evidence upon this point is very meagre.

Because of the paucity of fossils in both this formation and in the reputed Permian upon which it rests in different districts, little is known of any paleontological relationship between them. There are, however, some indications of such relationship that deserve mention. The case of the commingling of Mesozoic and Paleozoic types in the Permian of Texas has already been stated. Another case in South Park, Colorado, may be mentioned, and the possible occurrence of still another in southeastern Idaho may be suggested.

Important collections of plants and insect remains have been obtained from certain strata in South Park which are reported as immediately overlying rocks of unquestionable Carboniferous age. The plants are regarded by Professor Ward as constituting the most characteristic Permian flora that has been found on this continent. The stratigraphical relation of these rocks is also suggestive of their Permian age; and yet Mr. Scudder referred the insects to the Trias without qualification.

Some years ago Dr. Peale discovered in southeastern Idaho an unique assemblage of fossils in strata which rest conformably upon the Carboniferous and evidently occupy a position beneath the Triassic Red Beds, which occur in the same neighborhood. A part of the species belong to the Ammonitidæ and a part to the Ceratitidæ; and upon the evidence of these cephalopods Professor Hyatt referred the strata bearing them to the Middle Trias of Europe. When one remembers that cephalopod forms similar to those just referred to occur in India associated with a characteristic Carboniferous fauna, he naturally inquires whether it is not possible that the Idaho strata ought to be referred to a period not later than the Permian.

Those Idaho strata and the South Park and Texan Permian all possess great interest as indicating an intimate relationship between the Mesozoic and the Carboniferous of the Interior region; and if the record between the Paleozoic and the Mesozoic had not

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been so generally and so badly broken on this continent, we should doubtless now find many similar and more complete cases of the commingling of earlier and later types.

Some American field geologists have privately, if not publicly, expressed the opinion that the Permian ought to be assigned to the Mesozoic, rather than to the Paleozoic; but notwithstanding the paleontological relationship that has just been mentioned, such a view is untenable when all the known facts are considered. It is at present sufficient to say that the great break between the Mesozoic and Paleozoic of North America occurred while yet Paleozoic forms of life were far in excess of Mesozoic forms; and that almost all the North American strata that have been recognized as of Permian age appear to have been the result of continuous sedimentation from the Carboniferous. In short, all the hitherto recognized or reputed Permian of North America is far more intimately related both paleontologically and stratigraphically with the Paleozoic than with the Mesozoic. Therefore the lower delimitation of the North American Mesozoic must coincide with the base of the lowermost discovered Triassic strata.

A few hundred feet in thickness of strata, which have by common consent long been referred to the Jurassic, are found within a large part of the middle portion of the Interior region, resting conformably upon the Triassic strata which have already been noticed. Where these Jurassic strata have been fully studied, espeally in Colorado and Wyoming, they are separable into an upper and a lower portion, the lower portion being of marine, and the upper, of fresh-water origin. The invertebrate fossils of the upper portion are mostly of types that are now living and are, therefore, of no value as indicating their geological age. Those of the lower portion are few, and the cephalopods only, or mainly, present such characters as to suggest their Jurassic age; and it was upon this slight evidence, together with the relative position of the strata, that their reference to the Jurassic was first made.

Professor Marsh's well known publications of the remarkable dinosaurian faunas from both the upper and lower portions of the strata in question have left no reasonable doubt that they are really of Jurassic age. Professor Marsh refers all these strata to the Upper Jurassic of Europe; and in connection with this statement I wish to call your attention to the fact that wherever they have been found in contact with the Triassic strata already dis-

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cussed, they are not only strictly conformable, but they seem to have been the result of continuous sedimentation. In fact, it is paleontology alone that suggests an hiatus between them. The field geologist finds no evidence of it.

The Jurassic rocks of the Interior region disappear both to the northward and southward, their geographical range being apparently a little less than that of the underlying Triassic beds. No equivalent of the former has been found in Canada, although the Cretaceous Dakota Group, which immediately overlies the Jurassic further southward, has been recognized there. It may be remarked also that where the Jurassic is not present beneath the Cretaceous, the latter, especially in the eastern part of the region, is often found resting directly upon the older rocks, sometimes even upon the Archæan. In Texas the Jurassic is also absent from beneath the Marine formation, which is regarded as the representative of the Dakota Group there, the latter resting directly, but unconformably upon the Comanche beds, to be presently noticed.

Omitting present consideration of the isolated masses of reputed Jurassic rocks in western Nevada and eastern California, this subdivision of the Mesozoic seems to be represented in North America mainly by the slight accumulation of strata in the Interior region which has just been noticed. We know little or nothing of the flora which existed when these strata were deposited; their invertebrate fossils are of little value in determining their geological age, and if it were not for their dinosaurian faunas their Jurassic age might well be questioned.

The section of the Cretaceous formations which prevail in the central portion of the Interior region, and to which I shall more particularly refer in following remarks, differs materially from a similar section in the southern portion, usually known as the Texas section. Meek & Hayden divided the Cretaceous of the central portion of the region into the Dakota, Benton, Niobrara, Pierre and Fox Hills groups, the first mentioned being the earliest and the last one mentioned, the latest. In Texas, the Cretaceous section is continued much beneath the equivalent of the Dakota Group there. These lower Texan strata constitute the important marine formation now known as the Comanche beds, the molluscan fauna of which gives peculiar paleontological character to the Texan section. Above the Comanche beds there is a series of formations that are understood

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to respectively represent all the more northern formations which have just been mentioned.

After due consideration of all the known facts, some of which are of recent acquisition, there seems to be no room for reasonable doubt that the marine Cretaceous deposits of the Interior region which are later than the Dakota Group are, as a whole, not only equivalent with the marine Cretaceous deposits of the Atlantic and Gulf Coast region, but that they were all originally continuous through the whole of that great geographical extent. These formations are too well known to need present characterization; and they are now known to constitute the most extensive and definite taxonomic horizon that has been recognized among the Mesozoic formations of this continent. Furthermore the marine molluscan fauna of these strata is of such a character as to leave little room for doubt that they represent homotaxially the Senonian, and perhaps a part of the Danian, of Europe. The difficulty, however, of accurately correlating the Cretaceous formations of this continent with those of Europe is very great, as has, for example, lately been indicated by Professor Rœmer's reference of certain fossils of the Comanche beds to the Upper Turonian. These beds lie wholly and unconformably beneath the horizon of the Dakota Group which is itself not probably newer than the Cenomanian.

Before proceeding to a consideration of the Laramie Group it is proper to say that the presence in British America of the Kootanie formation beneath the Dakota Group, and that of the Comanche beds beneath the equivalent of the latter in Texas, shows that there is really an hiatus between the Dakota and the Jurassic in the Interior region, although their conformity is so complete that it has never been detected by field observation. If a similar hiatus exists between the Jurassic and Triassic in the same region, we have also no stratigraphical evidence of it.

The Laramie is in many respects one of the most remarkable of the North American formations. It is found occupying large portions of the Interior region from the state of Nuevo Leon in Mexico to beyond north latitude 52.° It reaches a maximum thickness of nearly 4000 feet in Colorado, and more than that in British America. It is not only everywhere conformable upon the Fox Hills Group, but wherever the junction between them has been seen sedimentation from the older to the later formation appears to have been continuous.

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In all its great geographical extent the Laramie Group has never been found to contain any animal remains similar to those which inhabit the open sea only. A considerable proportion of its invertebrates are like those which are now denizens of brackish waters, and a still greater proportion are fresh-water forms. It is mainly upon this abrupt change from a marine to a brackish- and fresh-water character of the molluscan fossils, and not upon stratigraphical difference, that we rely to determine the lower limit of the Laramie formation.

The labors of Dr. G. M. Dawson and Mr. Whiteaves, and their associates in the Canadian Survey, have shown that conditions similar to those which gave character to the Laramie formation existed in a large part of the northern interior region long before the close of the Fox Hills epoch, and that they were probably continued into the Laramie epoch. But time will not permit me now to discuss this interesting question.

Besides the invertebrate fauna which has just been referred to, a few insect remains, a rich flora and a somewhat extensive and varied vertebrate fauna have been obtained from the Laramie formation. None of the molluscan remains, so far as I can judge, possess characters which any similar forms might not have possessed at any time from the Middle Cretaceous to the Eocene inclusive; and a large part of them differ from living forms only as species.

Similar remarks may be properly made concerning the plant remains of the Laramie formation. Professor Ward has shown that of the one hundred and twelve genera of plants which have been discovered in the Laramie, thirty-eight of the genera and five of the species are common to the Dakota Group; eighty-five of the genera are living and twenty-seven are extinct. These extinct genera are all so nearly allied to living genera respectively that it is difficult to separate them. Furthermore, not less than three species from the upper strata of the Laramie have been identified with living species.

Mr. Scudder has referred the insect remains to the Tertiary, but the vertebrate remains, especially those of mammals and land reptiles, are of more ancient types than those of the plants and invertebrates. Among the few Laramie mammals that have been discovered there is no indication as to the ancestry of that great mammalian fauna which characterized the immediately following Wasatch period. The reptiles are mainly Dinosaurs of Cretaceous

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types, but some of them seem to possess characters that suggest their Jurassic age.

Some paleontologists have long hesitated to give an opinion as to the true taxonomic position of the Laramie Formation; but those who have studied the vertebrates only have usually referred it unqualifiedly to the Cretaceous, apparently assuming that, containing dinosaurian remains, it could not be of later age. Field geologists, especially those who practically ignore paleontological evidence, also refer the Laramie to the Cretaceous, because of its intimate stratigraphical relation to the marine Cretaceous beneath it, and because in all the principal displacements, which the latter has suffered in the Interior region, the Laramie was equally involved.

The formations which overlie the Laramie were, by common consent, long regarded as of Tertiary age; but concerning the age of some of them, differences of opinion have since arisen. Between the Laramie and any overlying formation there is often, but not always, unconformity. In Utah, and apparently in the valley of the Lower Yellowstone also, I have found the Laramie passing gradually up into purely fresh-water deposits without any stratigraphical break. In the former case I am sure, and in the latter case I believe with Professor Newberry, that the upper strata represent the lower part of the Wasatch Group.

In Utah several of the fresh-water molluscan species, which are widely distributed in the Laramie, are found to have passed up into the Wasatch; thus confirming the stratigraphical evidence of the immediate succession of the Wasatch upon the Laramie. In southern Wyoming dinosaurian remains are found in some of the uppermost strata of the Laramie; and the lowermost Wasatch strata in the same region bear Coryphodont and other placental mammalian remains; but remains of these two orders have never been found commingled. Still, in view of the facts just stated, it is not possible to doubt that those placental mammals lived contemporaneously with at least the last of the Laramie Dinosaurs.

In northwestern New Mexico and southwestern Colorado, Professor Cope has found certain strata at the base of the Wasatch, and overlying the Laramie, to contain the remains of a peculiar vertebrate fauna whose distinguishing members are placental mammals which are quite different from those of the Wasatch. These strata he designates as the Puerco Group, and he now refers them, together with the Laramie, to the Cretaceous, because of certain char-

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acteristics which the Puerco mammalian and reptilian remains present; but he formerly regarded that group of strata as of Cenozoic age. These Puerco strata have the appearance of having been deposited simultaneously with those which elsewhere constitute the lower portion of the Wasatch Group; and before their vertebrates were studied by Professor Cope their identity with the Wasatch was not questioned.

But we are not yet done with Dinosaurs. Mr. George H. Eldridge has lately shown that in the vicinity of Denver, Colorado, there is a distinct formation, from 600 to 1200 feet in thickness resting unconformably upon the Laramie, which he has called the Arapahoe formation. Mr. Whitman Cross has also lately shown that still another formation in the same district, having a maximum thickness of more than 1400 feet, rests unconformably upon both the Arapahoe and Laramie formations. To these strata he has given the name of Denver formation. The great aggregate thickness of these formations, together with their respective displacement with relation to the Laramie and to each other, shows that much time must have elapsed between the deposition of the uppermost Laramie strata in that district and the uppermost Denver strata.

Mr. Cross shows that a large part of the plant remains, which have been reported as coming from the Laramie in this district, really came from the Denver formation. Some of the fresh-water mollusca of the Denver strata I am not able to distinguish from Laramie species. But the most unexpected fact of all which these gentlemen have brought out is that both these formations above the Laramie contain dinosaurian remains in comparative abundance. The skull in some species is found to bear a pair of horns similar in posture and shape to those of the hollow-horned ruminants. Some of the bones also present characters which are suggestive of earlier Mesozoic age; but in a general way, at least, these Dinosaurs are similar to those of the Laramie.

The Laramie Group does not reach its maximum thickness in the Denver district, and it is not known whether the latest Laramie strata are represented there. Both the Denver and Arapahoe formations are of limited extent, and it is quite probable that the latter, and perhaps the former, together represent the later portion of the Laramie period. But it is reasonable to infer that at least the later portion of the Denver formation was contemporaneous with the earlier fresh-water Eocene strata of the Green River basin,

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notwithstanding the fact that the former bears dinosaurian remains.

The present state of our knowledge seems to justify us in regarding the marine Cretaceous formations immediately beneath the Laramie as representing the Senonian of Europe, perhaps including even a part of the Danian. Now if we add to the American Cretaceous the Laramie, Arapahoe and Denver formations, we evidently extend the Cretaceous in America much beyond its recognized latest limit in Europe.

But why, we may ask, should not those Dinosaurs have survived from Mesozoic, into Tertiary time? Why should they not have continued their existence as long as physical conditions were favorable, and as long as they could compete in the struggle for existence with such mammalian faunas as that whose earliest known history is recorded in the earlier strata of the Wasatch formation?

Before summarizing the conditions of the Mesozoic of the Interior region and proceeding to a consideration of the Pacific Coast section, I wish to refer to the relation of the Laramie Group with the marine Tertiary of the Gulf and the Atlantic coasts.

For reasons presently to be mentioned, no direct stratigraphical proof of contemporaneity of our great fresh-water inland deposits with marine coast deposits is possible, and direct paleontological proof is not to be expected. I had long hoped, however, that because the Laramie Group was in part of brackish water origin its continuity or contact with some marine coast deposit might be discovered. Such a discovery was first announced by Professor Cope, which I afterward confirmed and showed that in the vicinity of Laredo, Texas, the Laramie Group as a whole underlies with apparent conformity marine strata which contain an abundance of *Cardita planicosta* and other characteristic Eocene fossils; but I was not able to detect the continuity of the Laramie with any sea coast formation.

It was this discovered relation of the Laramie to the Gulf Coast Eocene that was referred to by the suggestion in a previous paragraph that there is really an important hiatus, although apparent conformity, between the Cretaceous and the Tertiary deposits of the Atlantic coast. The Gulf Coast Eocene just mentioned being regarded as equivalent with that of the Atlantic Coast, and the uppermost marine Cretaceous immediately beneath the Laramie, as equivalent with the uppermost marine Cretaceous of the Atlantic

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Coast, it follows that the hiatus referred to equals the whole of the Laramie. It may also be mentioned in passing that, both upon stratigraphical and paleontological evidence, I regard both the Northern Lignitic of Hilgard in Mississippi and its equivalent in eastern Texas as equivalent with the upper, lignite-bearing, portion of the Laramie as it occurs in the valley of the Rio Grande.

Very briefly summarizing the Mesozoic of the Interior region we find that its lower delimitation is greatly lacking in uniformity, the lowest member being sometimes the Triassic, sometimes, but rarely, the Jurassic, and sometimes the Cretaceous. The Triassic apparently represents the upper Trias of Europe, the Jurassic, the Upper Jura, and most of the Cretaceous, the upper part of that subdivision of the Mesozoic. Above the marine Cretaceous strata, inland sea and lacustrine deposits were continued into Tertiary time, apparently without a break, either paleontological or stratigraphical.

Having to deal with extensive inland deposits alone when investigating the immediate relation of the Mesozoic to the Cenozoic in the Interior region, we find that the most direct means of determining such relationship is wanting, because the continuity of the marine paleontological record is broken at the base of the Laramie formation. Still, the opinion that we have a continuous record there from Cretaceous, into Tertiary time, is strongly supported by paleontological and stratigraphical evidence. But we come now to consider the Mesozoic of the Pacific Coast region, where we shall find proof of unbroken continuity of marine deposits from the Upper Cretaceous to the Tertiary. Time will not permit me now to discuss the Mesozoic of western British America which Dr. G. M. Dawson, Mr. Whiteaves and other Canadian geologists have done such excellent work upon, and I must therefore confine myself mainly to the California section.

The rocks of this portion of the Pacific Coast region have been so greatly displaced since their deposition that their study is more difficult than that of the rocks of the Interior region. Still, our knowledge of the upper part of the Pacific Coast Mesozoic is quite satisfactory. The oldest Mesozoic strata of the California section which I shall specially refer to on this occasion were, by the California geologists, assigned to the Lower Cretaceous, under the name of the Shasta Group. But these strata do not probably represent the very earliest part of the Cretaceous period.

The exact relation of the Shasta Group to the Cretaceous forma-

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tions above it has not yet been made clear; but Mr. Diller's investigations in northern California seem to indicate that the hiatus between them is not so marked as has been supposed. The geologists of the California Survey did not recognize any formation as belonging between the Shasta and Chico groups, but Dr. G. F. Becker has reported upon a series of strata in Mendocino county which he believes to be later than the Shasta, and earlier than the Chico. Upon examining the fossils which he collected from those strata, some of the species of which have also been found at Todos Santos Bay in Lower California, I concurred in his opinion and suggested for those strata and their equivalents the name of Wallala Group. Still, actual contact of this group with any other Cretaceous strata has not yet been discovered, and its actual taxonomic position is not known.

From the base of the Chico Group upward the series of California strata which has been referred to the Cretaceous is so well known that little if any difference of opinion exists as to essential facts concerning it, although a wide difference of opinion has arisen as to their significance and importance. This series, aggregating more than ten thousand feet in thickness, was divided into two groups by the California geologists, namely the Chico below and the Téjon above, although they recognized the fact that there is no distinct break, either paleontological or stratigraphical, between them.

A considerable number of fossil invertebrates, among which are a species of Baculites and several ammonitic forms, constitute such a decided Mesozoic feature of the fauna of the lower portion of this Chico-Téjon series that the California geologists naturally and properly referred it to the Cretaceous. The upper, or Téjon portion contains a fauna that is so obviously Cenozoic in character that several geologists, especially Heilprin and Conrad, have strenuously contended that it is of Eocene age. A large proportion of these Téjon species are found to be so common in the Chico portion that if they were not there commingled with the Cretaceous forms just referred to, the Tertiary age of those lower strata would hardly be questioned. In short, there is in this stratigraphically unbroken Chico-Téjon series of California, a gradual transition of faunal characteristics from the Cretaceous to the Tertiary.

This transition was recognized by Mr. Gabb, and yet he referred the whole series to the Cretaceous. His view was that, a portion

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of the series being assigned to the Cretaceous, the remainder of it must follow, because the series can only be arbitrarily divided; and other geologists still entertain a similar opinion. By whatever name or names this great series of strata may be known, it is plain that it represents a continuous portion of geological time extending from the later Mesozoic, to the earlier Cenozoic age inclusive. Therefore the Mesozoic series of strata in this portion of the Pacific Coast region has really no definable upper limit.

It is true that by our present methods it is inconvenient to classify a series of strata like this, but the recognition of its true character is of far more importance than mere convenience of classification. Indeed this case constitutes one of the most instructive discoveries that has been made in the whole range of historical geology; and it should be understood as demonstrating that abrupt transitions from one epoch, period or age to another have always been due to local or regional changes in physical conditions; or in other words, to accidental circumstances.

Concerning the relation of the other members of the California section of the Mesozoic to the Chico-Téjon series, or to each other, and the relation of the lowest of those formations to the Jurassic, our knowledge, as before mentioned, is imperfect.

The satisfactory correlation of a part of the Cretaceous formations of the Interior region with those of the Atlantic Coast region has already been mentioned; but we have never been able to satisfactorily correlate any of the Cretaceous formations of the Pacific Coast region which have been mentioned, with any of those of the Interior and Atlantic Coast regions, even in cases of presumable contemporaneity. If such correlations are ever made we must expect them through the labors of the Canadian geologists in the Northwest. The whole fauna of each of the Pacific Coast formations referred to seems to be different from that of any of the more eastern formations, the few cases in which specific identity has been recognized being of doubtful character. This inability to correlate formations in different and not far distant parts of our own continent, which were presumably contemporaneous in their origin, may well cause us to doubt the correlation of at least a part of the American formations with those of other parts of the world which various authors have confidently assumed.

It has already been shown that the lower limit of the North American Mesozoic must coincide with the lowermost Triassic

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strata in any given section, whether those strata are regarded as representing the earlier or the later Trias; and that no strata hitherto recognized as Permian can be reasonably referred to the Mesozoic That is, the lower limit is defined by a great break in the geological record of this continent, constituting an hiatus, which began before the full completion of Paleozoic time and continued until after the beginning of Mesozoic time.

But we are quite unable to designate clearly the upper limit of the Mesozoic in at least a large portion of this continent. It is true that in the Atlantic Coast region the upper limit of the Mesozoic is clearly marked where the marine Eocene rests upon the uppermost of the Cretaceous strata there, but that delimitation is produced by an hiatus. In portions of both the Interior and Pacific Coast regions, however, it is quite impossible to clearly designate the delimitating boundary between the Mesozoic and Cenozoic, because in at least a part of both regions no break in either the stratigraphical or paleontological record occurred until after Cenozoic time was fully established.

In connection with the foregoing brief summary of the characteristics of the North American Mesozoic, certain views have been expressed which I entertain in common with some, but not all, other geologists concerning the correlation of formations and the interrelation of presumably contemporaneous fossil faunas and floras. The following propositions are offered as the basis of those views. A part of them, however, will not be questioned by any geologist, but these are given with the others for the sake of relevancy.

(1). In accordance with the principles of modern biology we must conclude that although it has not been demonstrated by actual discovery, there has been a continuous genetic succession of living organisms upon the earth ever since life began. That is, while numerous breaks in that succession have occurred, they have never been of universal, but only of local or regional extent; and they have been due to similarly restricted physical changes.

(2). The record of that succession of living organisms has been accomplished and preserved by the natural entombment of their fossilizable remains in aqueous sedimentary deposits. Subsequent physical changes have destroyed or rendered inaccessible a large part of the record, and all we know of that succession is derived from such of those remains as we have been fortunate enough to discover.

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(3). The record of the succession of terrestrial life has been far less complete, and has suffered greater interruptions, than that of aqueous life, because the record of the former has been made under conditions which were irrelevant, or inimical, to that life, and the entombment of its remains has always occurred under accidental conditions.

(4). The record of marine life is necessarily more complete than that of any other because the seas have furnished continuous, and more uniform, conditions than either the land or fresh waters, and because the preservation of its remains was a natural consequence of the conditions under which that life existed. Therefore the record of marine life was less modified by other than evolutional changes of a cosmical character than that of the land and fresh waters, and it is consequently more trustworthy as an index of the progress of geological time.

(5). Breaks or interruptions in the succession of marine forms of life have been coincident with breaks of continuity, or with changes in the characters of the sediments by which their remains were entombed. These breaks in sedimentation, and in the succession of living organisms, are used by all geologists as indicating the delimiting boundaries of geological epochs, periods and ages respectively; as well as of formations and systems. Their causes were independent of the existence of life, and their occurrence was accidental with reference to it.

It therefore follows that the recognizable time record in one part of the world is necessarily different in its divisions from that of any other part. For example, a period, the close of which was marked by such interruptions as have been mentioned in one part of the world would be continued in other parts as long afterward as the occurrence of similar breaks there should be postponed. While such interruptions were occurring in one or more parts of the world, life and sedimentation were continuous and unaffected by them in others. This is plainly shown in the case of the Chico-Téjon series in California, because no inter-delimiting boundary occurs between its Cretaceous and the Tertiary portions, as has already been explained; while an evident hiatus exists between the uppermost known Cretaceous and the lowermost known Tertiary both in Europe and a large part of North America.

(6). While there has been progressive development in the order of succession of living organisms from lower forms in earlier, to

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higher forms in later geological time, the rate of progress of that development has not been uniform in all parts of the world for the same kinds of life. For example, the plant life of North America is now understood to have reached, in later Mesozoic time, a higher stage of development with relation to animal life than it had in Europe; and the difference in grade among the now living indigenous faunas of the different continents respectively, indicates that a similar difference in the rate of development has also prevailed in different divisions of the animal kingdom.

(7). The various stages of progressive development of living organisms have been marked by the successive introduction and extinction of class, ordinal, family and generic types; and yet certain of those types survived in some parts of the world during long epochs after they had become extinct in other parts. This proposition is supported by such facts as that of the survival into the Laramie, Arapahoe and Denver epochs, of dinosaurian faunas which apparently show little if any indication of decadence or of approaching extinction; and also by the survival of highly organized representatives of Mesozoic families and genera to the present time. Therefore it is not to be expected that we should find exactly the same association of faunal and floral types; or evidence of more than approximately the same grade of development of life in contemporaneous, but widely separated formations. Therefore also, the custom which has been adopted by some paleontologists of making the assumed absence of certain of those types a distinguishing element in the chronological diagnosis of formations is by no means to be commended, even if it were possible for us to discover remains of all the forms of life which then and there existed.

(8). Correlation of lake and inland sea deposits with those of open sea origin, even within the same continental area, is necessarily a matter of uncertainty. This uncertainty is due to the great difference in the character of the faunas of those waters respectively, to the fact that constituent members of faunas of inland waters were not so diversely differentiated in the course of geological time as were those of marine waters; and also the inevitable want of geographical continuity of the two classes of deposits with each other, even in cases of actual contemporaneity. The only really trustworthy paleontological means of determining the equivalency or contemporaneity of deposits in such cases as these is the specific identification of such remains of land animals and plants

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as may have found entombment in then existing contiguous inland waters on the one hand, and marine waters on the other. For reasons mentioned in proposition 6, the mere similarity of types, even of the more highly organized animals and plants, which may be discovered in different districts cannot be relied upon as indicating contemporaneity. Geographical continuity of strata being always wanting in such cases the only aid to be expected from stratigraphy in determining equivalency of the formations must come through the discovery of the overlying or underlying position of the inland deposits with reference to marine deposits of known geological age.

It will be seen that these propositions involve serious questionings of the validity of certain methods and practices common among many of those geologists who devote themselves mainly or exclusively to paleontology. Such questionings afford scope for elaborate and varied discussions, but I shall close my present remarks with only a brief reference to the general subject of a proper recognition of a universal scheme of geological classification, which must of course have a biological basis.

The greater part of my own geological studies having been prosecuted from a biological standpoint, I am naturally not disposed to underestimate the value of paleontology as a branch of geological investigation, nor to encourage, even by incidental utterance, those who do. But I am sure no greater harm can be done to paleontological science than either to encourage, or to fail to oppose, the erroneous views which some of its votaries are shown by their own publications to entertain. For example, it is apparent to every one who is at all familiar with paleontological literature that many authors assume to designate with precision the geological age of any and all fossils submitted to them, as well as the taxonomic position of the strata from which they were obtained, without reference to stratigraphy, or to any related geological fact.

Those paleontologists who make this unwarranted application of their science to systematic geology, all use the scheme of classification that has been established for Europe, and use it as if it were of infallible application to all other parts of the world, and also as if it were already absolutely perfected for that continent. While I have no inclination to question the general accuracy of the European scheme of classification for that continent, I do not hesitate to express the opinion that it is not of infallible application

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to other parts of the world, except as to its larger divisions, and that even in this respect it will need modification. That is, I hold that investigation of the formations which are found upon any given continent or great division of the earth's surface ought to be prosecuted first, with relation to one another, and second, with reference to their ultimate, not immediate, correlation with those of other continents or divisions.

It is true that the general consensus of geological thought and opinion has long been in favor of adopting the European scheme of classification in all, or nearly all, its details as applicable to all other parts of the world, and every considerate naturalist will treat such opinion with deference. But prevalence of opinion is by no means proof of its accuracy. None of the older naturalists present need be reminded of the great revolution in opinion that took place a little more than twenty years ago; and the older geologists will remember that the degree of displacement, the amount of consolidation, the crystallization and lithological composition, of strata, were once accepted by all geologists as indices of the geological age of the formations which they composed. Remembering these incidents in the history of natural science it does not seem unreasonable that present opinions should be frequently questioned, even those which are generally accepted.

I do not wish to be understood as condemning the scheme of classification now in use, nor even as recommending the present substitution of it by any other; but I insist that for universal application, it is plainly imperfect. A scheme of classification, as a working rule, is not only a convenience but a constant necessity; so constant indeed that I have not been able to present these remarks without its aid. But while the one which has been established for Europe ought by no means to be discarded, it ought to be used tentatively in each of the great divisions of the earth, and with reference to the ultimate establishment of a universal scheme after all those divisions have been thoroughly investigated.

The time has come when North American geologists can, and ought to, hold a commanding position in this respect; and when we have elaborated a scheme of classification for the formations of our own continent, it will have equal claim to the favorable consideration of the geological world with any other.

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PAPERS READ.

THE ORIGIN OF GNEISS AND SOME OTHER PRIMITIVE ROCKS. By DR. ROBERT BELL, Assistant Director of the Geological Survey of Canada, Ottawa, Canada.

[ABSTRACT.]

GNEISS being probably the most abundant rock in the crust of the earth, it is rather singular that geologists have not yet come to a general agreement as to its usual process of formation. I say usual, for gneissoid rocks may be formed in more ways than one. For example, the granitic materials of some dykes are occasionally found to have assumed a gneissoid foliation parallel to the walls of the dykes, but no one would pretend that this was the normal mode of formation of the continuous gneiss of half a continent.

It is conceivable that a gneissoid, or rather a streaked, appearance may have been developed in certain granitic or syenitic rocks by a flowing movement, while in a plastic state, but such an appearance would, I think, be only very limited and would differ from ordinary gneissic bedding. The parallel mottling or clouding and isolated patches of a gneissoid character sometimes met with in granite or syenite may even be accounted for in other ways than from flow motion.

The bedding of gneiss differs from the streaking of slags by flowing, in being in continuous sheets which generally differ much in composition as well as color. It is difficult to imagine how flow-structure could communicate a distinctly and uniformly bedded arrangement throughout a depth of about ten miles of strata which is the ascertained thickness of one section of the Upper Laurentian alone. The presence of enormous beds of limestone, traceable continuously for a hundred miles or more, in the midst of these gneisses appears to me to be fatal to the flow-structure theory. Pressure will not account for the bedding of the Laurentian rocks, for no amount of pressure would separate a homogeneous mixture into distinct beds consisting of the different minerals. Or if pressure could separate these constituents, why have certain areas remained as granite or syenite?

The composition of different superimposed beds of gneiss often differs greatly, some being highly micaceous, while this mineral is scarce in others lying above or below. Again, considerable thicknesses may consist almost entirely of felspar, quartz or hornblende alone. I might mention in passing that hornblende is a very abundant constituent of our

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gneisses — hornblende-gneiss being about as common as the so-called typical or mica-gneiss. Now a fused mixture of materials would not separate into layers of the different ingredients, and certainly not into such innumerable fine layers as make up the immense thicknesses of these gneisses. This is, I think, another fatal objection to the above theory. Then some of the bedded rocks of the Laurentian system bear such a close resemblance to or may rather be said to be identical with rocks which we can trace to a clastic and even sedimentary origin, that we are forced to conclude that they too have had a similar origin.

The Upper Laurentian rocks are differentiated into belts or groups of beds which can be traced over considerable distances on the ground and can thus be accurately mapped. After carefully working out a large area in this way Sir William Logan proved that the Upper Laurentian strata obey the ordinary structural laws governing stratified rocks when thrown into anticlinal and synclinal folds.

The lower Laurentian gneisses cannot be so easily separated into distinct belts, and limestones appear to be absent from this division, but many of them resemble the gneisses of the upper series so closely that it is altogether likely they had a similar origin. The lower Laurentian strata are more contorted and at the same time more solid or massive than the upper. They also occupy a much larger geographical area. In Canada the Upper Laurentian appears to be confined to a comparatively limited region extending from Georgian Bay eastward through the Ottawa valley and along the north side of the St. Lawrence. It also occurs in eastern Labrador and perhaps in Hudson's Strait.

In the country stretching from Lake Huron to Lake Temiscaming at the great bend of the Ottawa, and thence northward and in other directions, we have the best known and one of the largest areas of Huronian rocks in Canada. Having worked on these rocks for a number of years, I have had good opportunity for studying them and I beg to offer a few suggestions based on these observations, as to the origin of gneiss and some other primitive rocks.

In the region referred to we have vast quantities of a rock of which very little has hitherto been said by geologists. The late Mr. Alexander Murray mentioned certain varieties of it under the somewhat erroneous name of slate conglomerates. It is a grey or ash colored rock somewhat resembling sandstone, but usually massive or not separated into distinct parallel beds. It bruises readily under the hammer and may be easily broken or scratched, showing that it is largely composed of softer material than quartz. This rock as a matrix often contains large numbers of angular and rounded fragments of all degrees of coarseness from the size of pins' heads to that of pease, walnuts, a man's fist and even boulders. They consist for the most part of reddish quartz-felspar rock, granulite or binary granite, but fragments of other rocks occur in some varieties.

In the specimens which I have examined under the microscope the matrix is seen to consist principally of angular grains of felspar and rounded grains of quartz with a darker amorphous mineral filling the interspaces.

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Much of this rock might be called a volcanic ash or breccia. The portions which are most free from pebbles or fragments are like the gold-bearing "whin-rock" of the Nova Scotia miners. Some of it might be called sandstone, and much of it passes by insensible degrees into quartzite. It is, however, desirable to have a general name for this rock and I know of no single word which will better describe it than greywacké. Now this greywacké seems to me to be the raw material out of which some of the other Huronian rocks of this region have been formed. And from a study of the transformation of one rock into another I have come to the conclusion that the origins of several kinds of crystalline rocks have points in common and are mutually dependent on one another in a larger measure than we may have supposed. Thus if we can account for the origin of gneiss we shall have incidentally accounted for that of some other crystalline rocks at the same time.

Another rock which is very common in some parts of the area referred to is quartz-diorite. It presents considerable variety of conditions with the same constituents, passing from the purely crystalline kind through several stages less or more modified by water, as if it had flowed out under the sea and been variously affected by the water according to the volume of the rock-matter present; or in other cases it seems to have been entirely broken up and modified by the sea, the constituents without the addition of anything else resulting in an aqueous deposit. The quartz-diorite is another parent from which some of the other Huronian rocks are derived.

But to return to the greywacké, there are plenty of examples in this region which show that it passes directly into different varieties of quartz-syenite and gneiss and also that these rocks, as well as quartzites, clay-slates and dolomites may be derived from it.

In the direct formation of gneiss the materials of the more slaty varieties of the greywacké in some cases appear to separate somewhat into laminæ by a process of segregation. In other cases they gather themselves into grains or spots by a species of concretion. The complete conversion of these into finished gneisses is effected by a slightly further alteration through the agencies (whatever they may have been) which have produced the metamorphism of the crystalline rocks in general.

On the other hand the more massive varieties of the greywacké may be seen to change gradually into imperfect and then perfect or thoroughly crystalline quartz-syenite. The process seems to be largely due to concretionary action, both on a small and large scale.

The breaking up and modification of the materials of the greywacké by water appear to give rise to a great variety of quartzites on the one hand, and to clay-slates on the other. These materials may have been thrown into the sea either as mud or dust and become separated and deposited at once in different places as quartz-sand and clay, or the rock, after partial or complete consolidation, may have become broken up and reduced by the action of water so that the quartzose and the argillaceous portions could become separated and each deposited by itself, to form the quartzites and

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clay-slates, which almost always accompany each other, as well as the greywackés of this region. The very fact of the association of these rocks suggests a connection of all these or a dependence of the quartzites and clay-slates upon the greywackés. The clay-slates frequently have layers of hornblende developed in them parallel to the bedding.

The quartzites are often largely mixed with the softer material of the greywacké, being in these cases merely the more silicious varieties of this rock which pass by insensible degrees into ordinary quartzite. The quartzite, however, is never entirely free from disseminated particles of felspar and this mineral in a crystalline form may be present in all proportions up to nearly half the whole mass.

These crystalline grains of felspar are generally light red in color and on very old surfaces they become dissolved out leaving little holes or pits. On slightly weathered surfaces they assume an opaque white, contrasting with the vitreous lustre of the quartzite, so that these surfaces have a speckled appearance. Where the felspar is uniformly and thickly scattered through massive quartzite, the rock is really a quartz-felspar or binary granite except that it has not yet become entirely crystalline but this change might readily be accomplished in time.

Where the felspar grains are disposed more thickly in rows in cross section, the rock looks very like gneiss even to the naked eye, and still more so under the microscope; and it might be converted into this rock by more complete alteration. On the west side of Lady Evelyn Lake between Temagami Lake and the Montreal River there is a mountain ridge 1,100 feet high, largely composed of this rock, standing nearly on edge, which a casual observer might easily take for gneiss although on closer examination it may be seen to be of clastic nature. The quartzite beds or quartzose gneisses of the Upper Laurentian in the county of Ottawa often contain felspar grains or crystals which weather out just like those of the Huronian quartzites and the outward appearance of the two rocks is so similar that hard specimens could not be distinguished from each other.

The curious varieties of modified quartz-diorite which have been mentioned are very abundant in some parts of the region under consideration —notably in the township of Denison. Extensive sections may be seen made up of beds of different thicknesses, but mostly thin, in each of which the quartz grains and the other components have been roughly separated from each other by the action of water. The bottom of each bed consists almost entirely of rounded grains of quartz; but, as we ascend, these become more and more mixed with argillaceous material till at the top there is pure clay-slate. The same arrangement is repeated in all the beds. In the vicinity of these beds there are others entirely of quartzite and of clay-slate, which I believe owe their origin to the disintegration of the quartz-diorite (probably when in a soft condition) and the separation and transportation of the original ingredients by water. If the thin alternating layers of quartz grains and slaty material were completely metamorphosed they would result in gneiss. The rocks of this region therefore appear to show three ways by which gneiss may be formed, namely,

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by the direct conversion of the thin bedded or slaty varieties of greywacké, the alteration of the mixed quartz and felspar rock derived from other varieties of it and the alteration of the modified quartz diorites. I have also found a case where what appeared to have been a comminuted mass of felspar and decomposed hornblende which may have been derived from diorite was separating into interrupted layers of pure felspar with others of schist which by further alteration would form a rock like gneiss.

The clay slates associated with the greywackés are, in some parts of the region, black or nearly so. On the Onaping river these may be traced into a black breccia which is clearly of volcanic origin, largely developed near Onaping station on the Canadian Pacific Railway, which would show that the black color in Huronian slates is not necessarily organic and that any theory based on the supposition that it is so may be erroneous.

The dolomites of this region are evidently in most cases of a concretionary or segregated nature, and have probably been derived from the decomposition of the hornblende or the augite of the rocks with which they are associated. Small unstratified masses of this rock are not uncommon in the diorites, syenites and greywackés where they have been formed *in situ*, while the layers and stratified deposits may have been precipitated from waters which carried the carbonates of lime and magnesia to short distances from the hornblendic or augitic-bearing rocks undergoing decomposition.

During the process of converting the greywacké into syenite, the diffused iron which it contained has been gathered either into great numbers of strings or small veins of magnetite or into a few larger ones of the same ore which, however, I have never seen wide enough to be worked. Veins of this kind are interesting as showing the probability of the formation of more extensive larger ones of iron oxides without the existence of organic life as a means for the concentration of the metal.

The above notes touch on nearly all the stratified and some of the unstratified rocks of this Huronian region and it is hoped that they may have suggested some points of interest for discussion.

ON CERTAIN REMARKABLE NEW FOSSIL PLANTS FROM THE ERIAN AND CARBONIFEROUS, AND ON THE CHARACTERS AND AFFINITIES OF PALÆOZOIC GYMNOSPERMS. By Sir WILLIAM DAWSON, Principal McGill College, Montreal, Canada.

[ABSTRACT.]

THE paper describes a new genus and species, *Dictyocordaites Lacoi*, discovered by Mr. R. D. Lacoe in the Catskill formation in Pennsylvania, also specimens of the fructification of *Dolerophyllum*, collected by Mr. Lacoe, and specimens of *Tylodendron* collected by Mr. Francis Bain in the Permocarboniferous of Prince Edward Island. The affinities of these plants are then discussed, and their relations to other gymnospermous plants of the Palæozoic, in connection with a review of the present state of knowledge of Palæozoic gymnosperms.

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THE REALITY OF A LEVEL OF NO STRAIN IN THE CRUST OF THE EARTH. By Prof. E. W. CLAYPOLE, Akron, Ohio.

[ABSTRACT.]

THIS paper contains a brief review of some recent discussions on this subject and presents in an untechnical manner the principal proposition and the reason by which it is supported. According to the mathematicians the cooling shell of the earth is contained for purposes of calculation between the surface and the depth of four hundred miles. Within these limits therefore nearly all the effects of cooling must be exhibited. The two chief factors in the problem are the cooling and contraction of each successive shell of small thickness and the subsidence of every layer in consequence of the shrinkage of those below it.

The shrinkage by cooling of each layer being greater toward the bottom of the series than the loss of room incurred by descent to a lower level, the curve representing the former lies at a greater distance from the axis than that representing the latter. But the former reaches a maximum and begins to diminish toward the surface while the latter constantly increases upward. Consequently, there must be a point where these loci intersect and this point of intersection will indicate the position of the shell of no strain. The paper concludes with some notes on the position of this shell in early times and with some geological reasons that set limits to its depth at the present day.

OBSERVATIONS ON SOME OF THE TRAP RIDGES OF THE EAST-HAVEN-BRANFORD, CONN., REGION. By E. O. HOVEY, Ph.D., Waterbury, Conn.

[ABSTRACT.]

THIS paper takes up a question that has been discussed by geologists with more or less vigor for the last seventy years. The region explored in connection with its preparation is a small one lying east and southeast of the city of New Haven, Conn., but it includes the Pond Rock region, which has been taken by Prof. W. M. Davis of Harvard (one of the latest and most voluminous writers on the subject) to be typical of the whole Connecticut Valley Triassic. After a brief description of the topography of the region, its long sandstone ridges and striking outcrops of trap, the writer discusses the character and age of the trap ridges. These are arranged in about six ranges extending about N.N.E. and S.S.W. one of which, Pond Rock, is perfectly continuous, but the others are broken up into numerous parts. The most western of these ranges is made up of undoubted dikes cutting obliquely across the strata of sandstone, and some members of the next two ranges east of this also show themselves as dikes. Professor Davis says that Pond Rock is an overflow sheet on account of "its small metamorphic effect at the base, its decided amygdaloidal texture on its back or upper surface, its irregular and brecciated structure, and its alteration

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and hydration." The writer's observations in this region and elsewhere lead him to conclude that no ratio between the thickness of a trap dike or sheet and the amount of induration of adjoining sandstone can be laid down, and that the extent of the induration of the underlying sandstone of Pond Rock is not a proof of the extrusive origin of the trap; that the amygdaloidal texture is not confined to the upper surface of an overflow but may occur in the interior of a dike or throughout the mass of an intrusive sheet; that the irregular and brecciated structure was produced by rapid cooling and subsequent alteration in places where the trap sheet was originally thinnest, and that the alteration and hydration are not as great as they are in a large undoubted dike in the western part of the region. The sandstones and shales overlying the trap of Pond Rock give positive evidence by their dipping at a much higher angle than the underlying sandstone that the trap sheet is intrusive and not extrusive in origin. The ranges east of Pond Rock also are intrusive. As to the age of the trap: Pond Rock and the range next west of it are probably older than the tilting of the sandstone, or of Triassic age, while the trap of the other ranges was probably intruded when the upheaval had been nearly or quite completed.

The communication was accompanied by a map on a large scale showing the position and shape of every exposure of trap (about 270 in all) in the region. The roads and watercourses were laid down partly from surveys by the U. S. Government and partly from surveys of the writer, but all by the trap ridges were put in from the writer's own observations.

THE DEVONIAN SYSTEM OF NORTH AND SOUTH DEVONSHIRE. By Prof. H. S. WILLIAMS, Ithaca, N. Y.

[ABSTRACT.]

AN account is given of an examination, recently made by the author, of the original Devonian sections and their fossils.

As a result of a comparison with the Devonian of the Appalachian basin and New York the conclusion is drawn "that (*a*) the fossils are very closely allied to the species in the New York Devonian, although in the great majority of cases passing under different names, and, (*b*) that the rocks in their appearance, composition and order are as different as two distinct systems well can be."

The Devon limestone of South Devonshire furnished the fossils upon which Lonsdale, in 1839, based his conclusion that the fauna was intermediate between the fossils of Murchison's Silurian system and those of the carboniferous limestones, which led to the establishment of a "Devonian system."

When other European localities had furnished more perfect sections this

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fauna was recognized as a middle Devonian fauna; that of Pilton, Barnstaple, Braunton, etc., was a higher fauna and was called Upper Devonian.

But neither the order of sequence of the rocks nor the separation of the fossils into well defined faunas can be satisfactorily determined from study of these Devonian rocks alone. Although they have furnished geological nomenclature with a name for the system they are far from being typical of the Devonian system.

Comparison of the faunas of the European Devonian faunas with those of the Appalachian basin leads to the hypothesis that the marine faunas of the two areas had different histories. There is a continuity in the succession from the lowest to the highest faunas of the system in Europe which we do not find in the American series.

It is evident that the American Hamilton and lower faunas are more distinct from the corresponding middle Devonian faunas of Europe than are the "Cuboides" and upper Devonian faunas of the two areas from each other.

To account for these facts it is conjectured that a barrier separated the two faunas during the lower and middle stages of the Devonian, and that at the "Cuboides" stage an incursion of European species took place into the Appalachian basin, but this incursion was not complete and was stopped by the elevation which terminated the Chemung marine fauna in the New York region.

Also it is conjectured that the evidence points to an advance northward of the early carboniferous faunas of the central basin of North America, to take the place of the Hamilton and Chemung faunas which in large measure ceased.

THE GEOLOGICAL POSITION OF THE OGISHKE CONGLOMERATE. By Prof. ALEXANDER WINCHELL, Ann Arbor, Michigan.

[ABSTRACT.]

THE Ogishke Conglomerate is found in the basin of Ogishke Muncie or Kingfisher Lake, in the extreme northeastern part of Minnesota. It consists of a mass of vertical slates, mostly dark, argillitic, hard and thick-bedded, with cleavage coincident with the bedding, through which are distributed rounded pebbles of gneissic, quartzose and doleritic rocks, arranged in definite courses, and so firmly embedded that rupture of the formation passes with equal readiness through the pebbles and the matrix. These conglomeritic beds stand in the strike of the black silicious argillites of Knife Lake on the west, and of the argillites and sericitic schists of Vermilion Lake. The structural indications are that the conglomerate belongs to the iron-bearing formation of Vermilion Lake. But, the opinion has been advanced that it represents the Animike formation. The Animike is now well known from Thunder Bay of Lake Superior to Gunflint Lake,

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which is only twelve miles east of Ogishke Muncie. In a more southerly region the Animike extends a hundred miles further west. There are some plausible reasons for thinking the Ogishke belongs to the Animike. The object of the communication was to show that such an identification is incorrect.

The speaker's observations were cited, which show the Ogishke to be a part of the Vermilion iron formation. Citations were also read from the Canadian Reports, showing the character of the Animike formation or "lower group of the Upper Copper-bearing series" of Logan, and showing that nothing like the Ogishke is included in it. Citations were also read from the Reports of Logan, Macfarlane and Bell, showing that the so-called Huronian of Thunder Bay embraces a conglomerate *exactly* resembling the Ogishke. This lies near the bottom of the so-called Huronian, and unconformably underlies the Animike. The Vermilion iron-bearing series also unconformably underlies the Animike. The inference is that the Ogishke belongs to the Vermilion iron-bearing group, as it appears to. A further inference is that since the Animike agrees in character with the original Huronian, north of Lake Huron, the so-called Huronian of Lake Superior is older than the true Huronian, and the Vermilion iron-bearing rocks so generally referred to the Huronian have been misplaced.

ON A POSSIBLE CHEMICAL ORIGIN OF THE IRON ORES OF THE KEEWATIN IN MINNESOTA. By Prof. N. H. WINCHELL and H. V. WINCHELL, Minneapolis, Minn.

THE proper understanding of the limits of this discussion requires a brief statement of some recent stratigraphic determinations. It is evident that the papers of the late Prof. R. D. Irving[1] and of Prof. C. R. Van Hise,[2] while in the main considering the problem from the point of view of the "Huronian," have also embraced within the scope of the phenomena cited, a group of strata much older, which lie everywhere,[3] unconformably under the Huronian and which present a series of facts which are distinct from those appertaining to the Huronian as found in the Penokee-Gogebic and Mesabi regions. The confounding of two formations, and the placing in one category the chemical and structural phenomena that are separated into two series by a great time-interval, and by structural unconformity, have so complicated the problem that hitherto no theory has been found capable of covering all the facts. The existence of this widespread unconformity has been shown in recent reports on the geology of the northwest by A. C. Lawson, A. Winchell and the writers; and latterly it was

[1] *Am. Jour. Sci.* (III), XXXII, 255. [2] *Am. Jour. Sci* (III), XXXVII, 32.
[3] Compare the 17th An. Rep. of Minn. Geol. Surv. pp. 42–45.

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also recognized by Irving.[1] By Professor Irving, however, there had not been, prior to his death, so far as known, any reconstruction or limitation of his general theory of the origin of the iron ores.

It is the purpose of this paper, while not calling in question the explanation by Irving of the origin of the ores of the Huronian, to show specifically, a possible origin for those of the Keewatin as they are found in the Vermilion range in northeastern Minnesota.

That there is reason to account for the Vermilion ore on a different hypothesis from that which may be sufficient for the Huronian ore, is evident from a consideration of the following differences in the formations. The Huronian strata are of fragmental origin, accumulated by the slow process of sedimentation, and are siliceous; being banded by lines of deposition that fade from one sort into another by such insensible transitions as can be produced by successive variations in the forces of an ordinary sedimentary process. This structure not only pervades the rock that embraces the ore, but passes into the ore itself. The formation as a whole, and certainly the beds that embrace the ore, are made up of secondary grains derived from some other formation. In other words it is non-crystalline. (Irving, 3rd An. Rep. U. S. Geol. Sur. pp. 157–165. 16th An. Rep. Minn. Sur. p. 39.)

On the other hand, the strata that carry the iron ore deposits of the Keewatin, when not rotted *in situ*, are crystalline or sub-crystalline, and do not vary in composition like a sedimentary rock. They do not show, except very rarely, any transitions between the ore and the enclosing rock, and when they do show such a mingling the alternations are between two kinds of material, and without the intermixture of clayey substances. The two materials are the *ore itself* and the *country rock*. But the country rock is uniformly constituted of diabasic schist which shows either its direct origin from eruptive, basic rock, or its quick distribution and deposition in waters heated by volcanic disturbances; and but rarely has so much intermingled silica of secondary, sedimentary derivation, as to raise the per cent of silica above the limit of Von Cotta for a basic rock. At points remote from the ore lodes the proportion of silica increases, and it is besides not wholly of the characteristic chalcedonic sort that prevails in the ore and in proximity to it. But, instead, some part of the silica found in strata distant from the ore lodes is in the form of rounded grains of vitreous quartz such as is chemically deposited in ordinary quartz veins. Besides silica, an aluminous element also displays itself in the formation at points removed from the mines.

Another noticeable difference between the Huronian and the Keewatin ores consists in the gradual changes that are seen to occur in the Keewatin ore as the country rock becomes more and more crystalline, massive and diabasic. In passing eastward from Tower the hematite is seen to give place gradually to magnetite, *pari passu*, as the green schists assume the character of unmodified diabase; and in the vicinity of Snowbank lake

[1] *Seventh An. Rep. U. S. Geol. Survey.*

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the iron ores are magnetitic jasperoid lodes embraced in such massive diabase,[1] conforming in general with the strike of the rocks of the region, and still showing all their necessary relations to the Keewatin formation. These characters are found, not in the lower, often lake-filled, valleys, but on the hills at elevations of several hundred feet. No such phenomena have ever been reported from the Huronian. The eruptive, diabasic rock of the Huronian mines either underlies the iron-bearing strata unconformably, as described by Dr. Rominger, or is in the form of transverse dikes that cross both the country rock and the ore beds, as recently described by Van Hise.[2]

Not only in respect to age and geological relations do these ores differ, but chemically they are quite different. The points of dissimilarity are prominently revealed in making a comparison of their impurities. The Keewatin ores contain silica as their chief impurity, the amount of phosphorus, determining the Bessemer or non-Bessemer grade, not being noticeably different from the Huronian ore. But in respect to other impurities the Huronian ores contain about 300 per cent more manganese; about 400 per cent more sulphur; about 33 per cent more alumina; about 25 per cent less of magnesia; about 400 per cent more lime and about 400 per cent more water.[3] The Huronian ore is generally soft, and sometimes is a limonite passing to siderite. The Keewatin ore is hard, never limonitic, and has not been known to contain any carbonate of iron.

The objections to the eruptive hypothesis of Foster and Whitney, lately revived by Dr. Wadsworth, have been stated in the fifteenth report of the Minnesota survey, and it is not necessary to dwell upon them here. The extreme length to which Dr. Wadsworth is carried by his predilection for eruptive agencies is seen in his arguing[4] that the quartzyte at Republic mountain is eruptive. One of the chief obstacles to this theory is the novelty of the proposition to enclose fused silica in the same mass with crystalline hematite and require them to cool without chemical union, the former retaining an amorphous state and the latter not losing its crystalline structure. Another obstacle is the plainly sedimentary banding that the ore presents, *i. e.*, the jaspilyte, which is unlike any structure known to result from the cooling of molten rock, and which unmistakably reveals the action of water in the formation of long parallel bands or strata.

The difficulties of applying the theory of Irving, *i. e.*, the metasomatic substitution of oxides of iron for some preëxisting carbonate, appear when we search for the remains of the supposed older carbonate, and when we find that the country rock does not afford good reason to have expected the deposition of any carbonate: and also when we search for the remaining ingredients which the assumed metasomatic process may have

[1] *Am. Geol. Jan.* 1889, p. 19; *17th Rep. Minn. Sur.* p. 122.

[2] *Am. Jour. Sci.* (III), XXXVII, 32.

[3] These results are based on average analyses for 1888, published by Pickands, Mather and Co., derived from several thousand assays.

[4] Notes on the Geology of the Iron and Copper districts, *Bul. Mus. Comp. Zool.* Geol. Series, Vol. 1, p. 54.

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left in the ore. In short, the whole mass of geological and mineralogical environment, as seen in the Huronian rocks, is at variance with that seen in the Keewatin, and precludes the hypothesis that ordinary chemical substitution will account for the chalcedonic silica and the hematite of the jaspilyte lodes.

But that chemical processes played a prominent, if not a principal, part in the formation or the jaspilyte, and in the metamorphism of the strata of all the Archæan, there is no disposition to call in question.[1] It is here appealed to as the prime agent in giving origin to the chalcedonic silica and the iron ore of the jaspilyte.

In order that the physical circumstances which obtained during the age of the crystalline and sub-crystalline schists, *i. e.*, during the age of the Vermilion and of the Keewatin, may be fairly apprehended, and brought to bear upon this inquiry, it will be necessary to mention some inferences that have recently been wrought out by the study of the Archæan.[2]

It has been stated repeatedly, by G. M. Dawson,[3] by A. C. Lawson[4] and by the writers,[5] that the rocks of the Keewatin consist very largely of volcanic ejectamenta. These ejectamenta were received in oceanic waters. The volcanoes themselves were mainly submarine, and the products of any intervening stage of sedimentary quiet were buried under the lavas of the next quickly succeeding stage of eruption. Whether this eruptive stage was world-wide, in its production of this kind of basic schist, as seems very likely, it is not necessary here to inquire; but that it was one of great duration, and prevailed in all of northeastern Minnesota wherever this rock horizon has been examined, and extended into Manitoba, there is no longer any room to doubt. It is therefore necessary to inquire how such products as chalcedonic silica and hematite could have been formed in a sea that was at times seething and steaming with volcanic craters and earth-fissures, from which escaped molten material from below the thin crust. That this chalcedonic silica, involved closely with interbanded hematite, and grading into it by insensible variations inthe amount of iron present, was received in water and distributed by water, is indicated not only by the stratiform arrangement, but also by the presence, occasionally, but very rarely, of rounded grains of other silica, not chalcedonic, some of them being a quarter of an inch in diameter, embraced in the general mass of the jaspilyte and sometimes forming more or less distinct belts or pebbly patches in the jaspilyte, approximately parallel with the general strike. This fact effectually vetoes the eruptive theory, and demonstrates that there was no exception in favor of that theory, so as to produce a structure characteristic of sedimentation, through the agency of molten acid lava flows.

[1] A. Winchell, *Fifteenth Report, Minnesota Survey*, p. 196.

[2] *Seventeenth Annual Report*, Minnesota Survey, pp. 37–40.

[3] *Geology and Resources of the 49th parallel*, 1875, p. 52.

[4] *Geology of the Lake of the Woods*, Can. Survey Rep. 1885, C, pp. 49–54.

[5] *Fifteenth report, Minnesota Survey*, 1886, p. 221; *16th Report*, p. 108. *17th Report*, p. 37; *Am. Geologist*, Jan. 1889, Vol. III, p. 22. Compare, also, Foster and Whitney, on the "Azoic," *Report on the Lake Superior land district*, 1851, Part II, p. 67.

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When the character of some of the narrow bands of pure white and translucent silica is duly considered, and it is compared with the known product of chemical precipitation from silicious waters, the idea of *chemical precipitation* is forcibly presented as the possible origin for the chalcedonic silica of the jaspilyte. There is no way known in nature for the formation of chalcedonic silica except by chemical deposition. The different bands of the jaspilyte, varying in color from white to red, brown and sometimes nearly black, are all formed by the varying proportions of hematite and silica. Ordinary sedimentary action could not select from the products of erosion simply two substances and unite them in characteristic strata, when the ocean's waters must have been charged with suspended matter of many different kinds. Some selective, discriminating force was at work which was able to abstract silica, or silica and iron oxide, from the water and reject all the rest.

In the light of what has already been said regarding the nature of the schists enclosing the ore masses, it is plain that the waters of the Keewatin ocean were constantly agitated by volcanic eruptions. It is also plain that they must have been hot, and in some places, or after irregular intervals of time, must have been rapidly evaporated and at other times suddenly cooled. The earth's crust was thin and easily rent, and the contact of water and molten rock was frequent. The water became alkaline by solution from the lavas of the magnesia, potash and soda and other alkaline elements. In this condition it would also become surcharged with soluble silica and iron, obtaining the latter from the augitic minerals of the basic lavas, and possibly from masses of erupted metallic iron. Indeed, the ocean was a hot compound decoction of all the minerals that could be dissolved from the eruptive diabases; and of those minerals there was no exception.

Under such circumstances it requires no extensive research nor chemical foreknowledge, to predict what would be the result whenever the equilibrium of super-heated and super-saturated oceanic water was disturbed. Something would be precipitated. Would it be silica and ferric oxide?

On this point Hunt says[1]: "The atmosphere, charged with acid gases which surrounded the primitive rock, must have been of immense density. Under the pressure of such a high barometric column, condensation would take place at a temperature much above the present boiling point of water; and the depressed portions of the half-cooled crust would be flooded with a highly-heated solution of hydrochloric and sulphuric acids, whose action in decomposing the silicates is easily intelligible to the chemist. The formation of chlorides and sulphates of the various bases and *the separation of silica* would go on until the affinities of the acids were satisfied, *and there would be a separation of silica, taking the form of quartz*, and the production of a sea-water holding in solution, besides the chlorides and sulphates of sodium, calcium and magnesium, salts of aluminum and other metallic bases" . . . . "Quartz has not only never been met with as a

[1] T. Sterry Hunt. *The Chemistry of the Primeval Earth. Am. Jour. Sci.* Jan, 1858. *Smithsonian Report*, 1869, p. 189, *Chemical and Geological Essays*, 1878, p. 40.

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result of igneous fusion, but it is clearly shown by the experiments of Rose, that a heat even much less than that required for the fusion of quartz destroys it, changing it into a new substance, which differs both in chemical and physical properties from quartz." . . . . "The first precipitates from the waters of the primeval sea must have contained oxidized compounds of most of the heavy metals." "The large amounts of silica contained in solution in the waters of some thermal springs and of many rivers, are separated when these waters are exposed to spontaneous evaporation, partly as silicates of lime and magnesia, and partly in the forms of crystallized quartz, hornstone and opal. In many different formations beds are met with composed entirely of crystallized grains of quartz which have apparently been deposited from solution. In other sediments this element abounds in the form of grains of chalcedony or as amorphous soluble silica. The beds and masses of chert, flint, hornstone, buhrstone, and many jaspers, have all apparently been deposited from aqueous solutions."[1]

Prof. A. Winchell thus refers to this primeval ocean and the precipitation of silica:[2] "The liberated silica would separate and would be chemically precipitated during the subsequent cooling of the waters, and would thus give rise to the enormous beds of quartz which we actually find among the very oldest strata."

Concerning the similar production of beds of iron oxide, Hunt states:[3] "Those chemical compounds which were most stable at the elevated temperature then prevailing would be first formed. Thus, for example, while compounds of oxygen with mercury, or even with hydrogen, could not exist, oxides of silicon, aluminium, calcium, magnesium and iron might be formed. . . . . All the elements, with the exception of the noble metals, nitrogen, chlorine, the related haloids, and the hydrogen combined with these, would be united with oxygen. The volatility of gold, silver and platinum would keep them still in a gaseous condition at temperatures where silicon, and with it the baser metals, were precipitated in the form of oxides."

These quotations might be multiplied. The formation of siliceous and irony deposits from oceanic waters is referred to by Gustav Bischoff,[4] J. W. Dawson,[5] and by nearly all geologists who have written of the chemical reactions of the primeval ocean. Much speculative literature has been published relating to the early co-relations of the consolidating crust, the heated interior and the enveloping atmosphere of the earth. But very often no actual account has been taken of these theories in the practical work of the field geologist. The drama of sedimentation, and the erosion of shores, and the transportation of material by currents, forming the later strata of the super-crust, have been duly investigated, but this theoretical age of seething, alkaline, oceanic water, the actual causes that produced

[1] Hunt, *Geology of Canada*, 1863, p. 574.
[2] A. Winchell, *Sketches of Creation*, 1870, p. 59.
[3] T. Sterry Hunt, *Smithsonian Report*, 1869, pp. 186, 189.
[4] *Chemical and Physical Geology* (Cavendish Society) Vol. I, pp. 143, 146.
[5] *Quart. Jour. Geol. Soc.*, Vol. V, p. 25.

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it, the resultant rock that attests its existence and the position it holds in the strata of the Archæan, have not had their analogous demonstration and adequate description in geological literature. The writers believe that the Keewatin age was characterized by these forces and events and that the green schists, whether sericitic or chloritic or diabasic, that fundamentally constitute the bulk of its rocks, and the jaspilyte lodes, exemplify the chemical precipitations and the mechanical depositions that the theories require. So long as the term "Huronian" was made to cover the actual Huronian strata, as well as all lower beds down to the Laurentian base, it was difficult, if not impossible, to invoke world-wide forces in one portion of the stratification that nullified those that were demanded to produce the rocks of the other. By the separation of the Keewatin from the Huronian a different set of conditions may be relied on, but none other than those that are needed to produce the rocks which are found to compose it.

It is not the purpose of this paper to explain any of the physical conditions of the jaspilyte, nor of the strata that compose the bulk of the Keewatin, such as brecciation, folding and involute contortion, compression, fracturing and transportation of strata once formed, the upheaval and prevailing verticality of the beds. These, in the main, must have been produced subsequent to the chemical precipitation here appealed to to explain their origination, but to a certain extent seem to have been contemporary with the precipitation of the beds themselves. But it is our sole purpose to account for the existence of the jaspilyte by some hypothesis consistent with known chemical laws, and in accordance with such surroundings and physical forces as the nature of the Keewatin rocks shows to have obtained at the time of its formation. This hypothesis not only is consistent with these laws and conditions, but it explains some of the features of the jaspilyte which no other theory, so far proposed, will explain. Some of these peculiar features may be mentioned, namely: (1) It accounts for the minutely fine structure of the silica, and for the uniformity of its granular texture upon disintegration; (2) It accounts for the prevalence of this structure at all depths in the earth, wherever the jaspilyte is found to extend; (3) It accounts for the agate-like banding and the minuter lamination that characterize the jaspilyte; (4) It furnishes an explanation for the purity of the white chalcedonic ribbons, which consist of silica only; (5) It explains the re-cementation of some of the thin, brecciated layers by material of the same kind as the layer itself; (6) It explains the occasional intrusion of rounded grains of non-chalcedonic quartz into the mass of chemically precipitated quartz; (7) It explains, lastly, the occasional mingling of chalcedonic silica with the finer elements of the basic schists, forming regular sedimentary alternations.

Summary. All attempts hitherto made to account for the existence of the iron ores of the Northwest, particularly those of Professors Irving and Van Hise, have confounded the phenomena of two unconformable formations that manifest constantly distinct contrasts of stratigraphy and lithology.

The theory of Foster and Whitney, that these ores are of eruptive ori-

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gin, is opposed by chemical laws and by structural peculiarities that cannot be reconciled with it.

The ores of the Keewatin are markedly different from those of the Huronian in their chemical impurities.

The theory of metasomatic substitution of iron oxide for some carbonate, while applicable to the ores of the Huronian on the south side of lake Superior cannot be made to account for the ores of the Keewatin, because, (1) There is no evidence of the existence, at any time, of the necessary earlier carbonate; and (2) The nature of the country rock embracing the Keewatin ore is such as to imply that no carbonates, in the amounts required by the theory, could have been deposited at the time the rocks were being formed.

There is therefore necessity for some other explanation than that applicable to the Huronian ores.

Chemical precipitation in hot oceanic waters, united with simultaneous sedimentary distribution might produce the Keewatin ores in a manner consistent not only with the physical conditions that prevailed at the time of their formation, and with the structural peculiarities which they exhibit, but also in accordance with the known reactions of heated alkaline waters, and with the chemical character which the ores are known to possess.

THE EAGLE FLATS FORMATION AND THE BASINS OF THE TRANS-PECOS, OR MOUNTAINOUS REGION OF TEXAS. By ROBERT T. HILL, University of Texas, Austin, Texas.

[ABSTRACT.]

THE portion of Texas west of the Pecos river is described as a series of complicated mountain disturbances, accompanied by much faulting and eruptive material. The largest portion of the area, however, consists of extensive flats lying between the mountains, which are shown to be almost recent lake beds, drained of their waters, except in rare instances where salt lakes still occupy limited portions of these basins. The quaternary or later sediments of these former lakes are described as the Eagle Flats formation.

THE IGNEOUS ROCKS OF CENTRAL TEXAS. By R. T. HILL and E. T. DUMBLE, University of Texas, Austin, Texas.

[ABSTRACT.]

PILOT Knob, Travis County, Texas, is described as the type of an intermittent line of basaltic rocks often of columnar structure protruding through the cretaceous limestones of Central Southern Texas from east of

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Austin to the Rio Grande. The age is shown to be Post Eocene, and the name Shumard system is proposed for this hitherto unclassified eruptive topographic feature.

These eruptives (?) extend a little north of east from the Rio Grande in the vicinity of Fort Clark, to Austin, Texas. The isolated eruptive areas of Rockwall county, Texas, and Pike county, Arkansas, are in line with this system, and probably all are along a line of weakness in the earth's crust which has apparently existed in this region. The time of the eruption is shown to have been Post Eocene.

THE GEOLOGY OF THE STAKED PLAINS OF TEXAS, WITH A DESCRIPTION OF THE STAKED PLAINS FORMATION. By R. T. HILL, University of Texas, Austin, Texas.

[ABSTRACT.]

THE Staked Plains are shown to be an extensive mesa, which was an interior base level in late Tertiary or early Quaternary time. Its surface is covered by a fresh-water lacustral sediment, consisting of loam and gravel for which the name of the Staked Plains formation is proposed.

THE GEOLOGY OF THE VALLEY OF THE UPPER CANADIAN FROM TASCOSA, TEXAS, TO TUCUMCARRI MOUNTAIN, NEW MEXICO, WITH NOTES ON THE AGE OF THE SAME. By R. T. HILL, University of Texas, Austin, Texas.

[ABSTRACT.]

THIS valley is shown to have been a more ancient piece erosion than that accomplished by the present river which flows through it. It is from forty to sixty miles wide and eight hundred feet beneath the ancient base level of the staked Plains, and filled with a detrital deposit for which the local name of the Terra Blanca formation is proposed.

A CLASSIFICATION OF THE TOPOGRAPHIC FEATURES OF TEXAS WITH REMARKS UPON THE AREAL DISTRIBUTION OF THE GEOLOGIC FORMATIONS, WITH MAP. By R. T. HILL, University of Texas, Austin, Texas.

[ABSTRACT.]

THE Texas region is described and its topographic features defined as a series of ancient base levels, striking approximately north and south, and limited by two orographic systems, the more ancient and northern

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one being the Onachita system of Branner, in Arkansas and Indian Territory, and the southern, the mountains of northern Mexico and the Trans-Pecos region of Texas. Certain conspicuous valleys of erosion are explained, and the progress of denudation described. The relation of this topographic classification to the cultural possibilities of the region, and to the distribution of the floras and faunas is also shown.

A NOTICE OF SOME ZIRCON ROCKS IN THE ARCHÆAN HIGHLANDS OF NEW JERSEY. By FRANK L. NASON and WALTER F. FERRIER, Assistant Geolgists, Survey of New Jersey, New Brunswick, N. J.

[ABSTRACT.]

DURING the progress of the New Jersey Geological Survey in the autumn of 1888 and the summer of 1889, several localities of a peculiar zircon rock have been observed.

In the report of the Geological Survey of 1868, mention is made of a zircon-bearing gneiss at Trenton.[1] Zircons were reported also from Swede's mine,[2] Rockaway township; and also at Wawayanda mine,[3] Vernon township.

If other localities were known at this time, no mention was made of the fact.[4] With the exception of the Trenton gneisses, the mineral was found in the ores of the mines. Zircons have since been found in many of the iron mines, but in rather minute crystals and in sparing quantities. The localities in question, however, present marked exceptions to the above-mentioned occurrences. The mineral is a very prominent constituent of the rock, amounting, in some masses, to nearly twenty per cent of the specimen. The average would probably reach five per cent of the mass. The other minerals composing the rock are magnetite, titanic iron ore, quartz, feldspar (orthoclase and plagioclase) and hornblende. Accessory minerals are sphene, rutile, biotite and probably pyroxene.

In structure, foliation and bedding are wholly absent. The quartz is often porphyritic, sometimes having the peculiar appearance of quartz in graphic granite.

In the field, at the three localities observed, the rock, as a whole, has the appearance of a huge eruptive boss or a volcanic neck. Fragments of other rocks appear to be enclosed in the mass. Certainly, there do occur foreign rocks, but whether these are fragments included in an eruptive mass or only portions unchanged by a reworking of the rock mass, it is not at present possible to determine. This much is certain, however, that the position and appearance of the rocks in the immediate neighborhood lend abundant support to the eruptive hypothesis.

[1] Ann. Rep. State Geol. Survey, 1868, Dr. Geo. H. Cook, State Geologist, p. 333.
[2] Ann. Rep. State Geol. Survey, 1868, Dr. Geo. H. Cook, State Geologist, p. 333.
[3] Ann. Rep. State Geol. Survey, 1868.
[4] Mention is made in the former reports of Rogers.

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The abundance of magnetite in the rock is so great as to give considerable dip to the miner's needle. This led to the search for workable deposits of iron ore, and the numerous shafts thus sunk afford opportunity to study the rock to some depth below the surface. The idea of working the localities for iron ore is now abandoned, but it is a fair question as to whether the zircons, occurring as abundantly as they do, may not be of economic importance, provided that a cheap method of separation can be devised.

The survey made experiments with this end in view. A sluice box, twelve feet in length, was employed. No zircon was observed in the tailings, but was found to be caught with the magnetite and titanic iron on the first three riffle bars. This mixed material, subjected to the action of a powerful electro-magnet, frees the zircon from the ore and leaves it pure. The magnet must be a powerful one on account of the presence of titanic iron.

The process of preparing the rock for washing is facilitated by the ready separation of the zircon crystals from their matrix. A crystal exposed in a rock needs only a slight tap to detach it.

The most interesting feature of the rock is the zircon crystals which are well developed and of a beautiful, reddish-brown color. Some of the smaller ones are almost transparent, resembling the hyacinth variety of the mineral. In a hurried examination of the crystals, the principal planes observed were ∞P, P $3P$, $3P3$ and $\infty P \infty$, but many undoubtedly occur, and the locality might afford interesting material for crystallographic study, as the planes in the smaller crystals are well formed and brilliant and so admirably adapted to measurement. Twins occur, the twinning plane being $P\infty$ as in the crystals from Renfrew, Ontario. A large proportion of the crystals exhibit the ditetragonal pyramid.

The crystals vary in size from microscopic needles to about 5 mm. in diameter and 25 mm. in length. The average are about 2 mm. in diameter and 5 mm. in length. They nearly all exhibit a curious lateral compression, are often bent and present the peculiar pitted or corroded appearance so often seen in apatite. Surface specimens in many cases have a most brilliant iridescent tarnish.

The convexity of the pyramidal faces, so characteristic of the species, was frequently observed in the larger crystals.

This interesting rock is now under investigation by the survey and further particulars will appear in the next annual report.

NOTE ON THE MAPPING OF THE ARCHÆAN NORTHWEST OF LAKE SUPERIOR. By Dr. ANDREW C. LAWSON, Ottawa, Ont.

[ABSTRACT.]

THE writer exhibited a general geological map of the Archæan country between Red River Valley and Lake Superior, showing the results of recent investigations which he has been conducting for the Geological Sur-

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vey of Canada. The proof of a new geologically colored map of the Rainy Lake region, shortly to be issued by the survey, was also exhibited to illustrate the details of a portion of the general map. The relative distribution of the Upper and Lower Archæan, as displayed on the map, was shown to be peculiarly interesting and instructive. The Lower Archæan or Laurentian, consisting of various, more or less foliated granites and syenites, which have hitherto been regarded as the oldest rocks, was shown to occupy large, isolated boss-like areas which appear to be irruptive or intrusive through the schists. The general mapping of this portion of the country, where denudation has left the Upper and Lower Archæan in nearly equal proportions, strongly supports the view that the Laurentian rocks are of later age than the schists of the Upper Archæan and were irrupted through them.

The importance of careful mapping as an aid to the solving of the profound problems of Archæan geology was dwelt on, and other evidence which the writer has adduced elsewhere in support of the irruptive nature of the Laurentian was referred to.

PETROGRAPHICAL DIFFERENTIATION OF CERTAIN DYKES OF THE RAINY LAKE REGION. By Dr. A. C. LAWSON and F. T. SHUTT, M. A., F. C. I., Ottawa, Ont.

[ABSTRACT.]

ONE of the writers has described in a former paper certain diabase dykes of the Rainy Lake region. The present paper is the result of a more critical investigation of the same dykes, with others since discovered, having special reference to the petrographical differentiation of the dyke rock in passing from the contact walls to the centre of the dyke. The fact that dykes are very commonly fine grained at their margins and coarse grained in their middle parts is familiar to all geologists. On examination of the dykes in question, it became apparent that this variation in the physical appearance of the dykes is not simply one of *texture* or degree of coarseness of the constituent minerals, but that it is rather the incidental concomitant of important *structural*, *mineralogical* and *chemical* variations which appear very constantly in the same way in different dykes. These variations are chiefly as follows: *Structural*—the passage from the structure of a very fine textured diabase-porphyrite at the contact walls through the characteristic ophitic structure of diabase at a few feet from the contact to the granular structure of gabbro in the middle part of the dyke. (Illustrative drawings were submitted.) *Mineralogical*—the passage from a quartzless rock at the contact to a quartzose one towards the middle of the dyke. *Chemical*—the passage from a more basic rock near the contact to a more acid towards the middle. The results of complete or partial analyses by Mr. Shutt of series of specimens taken across a number of dykes were given in tabular form.

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The principal object of the paper is to adduce specific evidence that from a rock mass which is a geological unit of very limited extent, there may be taken specimens which under current methods of classification would receive different names and be relegated to different classes. The fact that a series of specimens, in any given locality, differ from one another texturally, structurally, mineralogically and chemically, is no proof that they are not geologically the same rock crystallized from the same magma. The regular textural and structural differentiation of the dykes from wall to middle is inferred to have been caused by the different rate of cooling under constant pressure. The chemical differentiation is probably due to a selective crystallization of the more basic minerals in the earlier stages of solidification accompanied by the transference of acid residues from the sides to the middle by the agency of included water.

THE LAKE RIDGES OF OHIO AND THEIR PROBABLE RELATIONS TO THE LINES OF GLACIAL DRAINAGE INTO THE VALLEY OF THE SUSQUEHANNA. By Prof. G. FREDERICK WRIGHT, Oberlin, O.

[ABSTRACT.]

THE map of the glaciated area of the eastern part of the United States shows that the sides of the angle formed by the ice-front at Salamanca, N. Y., are closely parallel with the shores of Lake Erie, to the northwest and to the course of the valley of the north branch of the Susquehanna and its extension up the Chemung and Canisteo rivers, on the northeast. In consequence of this parallelism it is evident that the colls from the Erie-Ontario basin into the Susquehanna valley must have been uncovered simultaneously with the retreat of the ice from the south shore of Lake Erie. It is probable, therefore, that the lowest of those colls, that south of Seneca Lake, which is only a trifle higher than the upper ridge south of Lake Erie, controlled the level of the glacial lake, Erie-Ontario, for a considerable period of time, or, until the ice had retreated far enough southwest of Lake Erie to uncover the coll leading from the Maumee into the Wabash river which is about the level of the lower of the lake ridges. The approximation of these levels, namely, that of the Lake Seneca coll and that of the Fort Wayne coll, to the level of two prominent lake ridges is extremely suggestive of a causal connection between the two sets of phenomena.

Facts were presented illustrating the extent and character of the deposits of loam and gravel in the vicinity of these various colls, especially that at Portageville, N. Y., and of other places in the headwaters of the Susquehanna river. These facts apparently shed some light on the origin of the loess and on the deposits at the head of Chesapeake Bay, which for a long time received the glacial drainage, both from the upper part of the Susquehanna valley itself and from the vast region farther back which furnished the surplus waters of the glacial lake, Erie-Ontario.

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GLACIAL PHENOMENA OF NORTHEASTERN ILLINOIS AND NORTHERN INDIANA. By FRANK LEVERETT, U. S. Geological Survey, Madison, Wisconsin.

[ABSTRACT.]

THE paper opens with an explanation of the methods of study already employed and other methods to be employed in deciphering the history of the drift. A brief discussion is given of the features and phenomena included under the term moraine as restricted in the paper. Among these features, knobs and basins, swells and sags, smooth ridges of till, bowlder belts etc., are included, but the till plain or "ground moraine" is excluded.

The moraines here described are terminal to the *ice* but not to the drift-covered areas of these states.

Four evidences of advance in the production of later moraines are cited: (1) Buried soils *in situ* between till sheets; (2) Changes in the direction of flow as shown by striæ; (3) Change in form of ice lobe as indicated by the distribution of the morainic belts and shiftings of reëntrant and lobate portions; (4) Evidence of push or advance found in the moraine itself.

The number of distinct moraines varies because of partial coalescence or local obliteration of portions of certain moraines by later advances. For this reason correlation is difficult. Aside from the difficulty cited there is an increase in the complexity in passing from older to newer moraines. In the older ones the interlobate portions are short and the moraines can be followed around continuously from one lobe to another through the reëntrant portions; but in newer moraines the terminal loops meet on opposite sides of large interlobate moraines and correlation is made only after critical study of their connections, overriding, overwash, etc.

Suggestions are made upon the subject of progressive lobation, but caution is urged against advancing general schemes too early. The study has not been carried far enough to make it possible to draw conclusions of that high order to which future extension of the work will lead.

Before the leading time-intervals in this district can be properly outlined, wider correlations must be made and erosion studies must be completed.

TOPOGRAPHIC TYPES OF NORTHEASTERN IOWA. By W J MCGEE, U. S. Geological Survey, Washington, D. C.

[ABSTRACT.]

THERE are in the territory half a dozen distinctive types of topography: 1. The Wisconsin driftless area extends into the extreme northeastern part of the state, and exhibits a water-carved sculpture of the autogenetic

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order, and as seen in plan exhibits well the characteristic features of such sculpture; but the prevailing profiles are convex in a remarkable degree. This convexity indicates and illustrates a law of water-carving not hitherto recognized, viz., *the convexity of profiles is proportional to the excess of disintegration over transportation.* Taken in connection with other phenomena, the area expresses what may be called *the law of land profiles.* 2. About the margin of the driftless area the topography is a singular hybrid between water-carved and glacial sculpture; and it is noteworthy that it is not valley-bottoms but hill-summits which were most severely abraded by ice, showing that practically the glaciers rode the hills and bridged the valleys. 3. In the southwestern part of the territory, the Pleistocene ice-sheet evidently melted rapidly while standing near base level, and the drift and loess were fashioned by sluggish currents or waves into broad plains; and these plains have since been sculptured by autogenetic processes into characteristic forms which exceptionally well illustrate that order of topographic forms. 4. The same order of forms is still better illustrated by a small "gumbo" area in the extreme southeastern part of the area overlooking the Mississippi river. This area is representative of the extensive "gumbo" plains forming a large part of the tract overridden by the earlier ice-sheet but not by the later in Iowa, Missouri, Illinois and Indiana. 5. There is a large area in the central part of the territory in which the ice both moved and melted rapidly, but at such height above base level as to permit free drainage; and the sum of conditions here was such as to give origin to a unique and anomalous configuration. The principal drainage is not in the direction of, but approximately at right or even less angles to the prevailing slopes; the water-ways flowing across or partly against the general slopes do not seek the lowest lines, but frequently avoid low-lying plains and valleys and flow in narrow cañons cleaving the axes of long ridges and dividing high plateaus; and the uplands are traversed by elongated ridges and systems of elliptical hills separating lower plains to such an extent that the whole surface over an area of 3,000 or 4,000 square miles takes on a Titanic ice-moulding as distinctive as the flutings and striæ of ice-worn ledges. These unique ice-moulded ridges and swells approach the aasar of Sweden and the kames of Ireland in form, but are more regular in arrangement and are also unique in composition—their materials being loess, sometimes fossiliferous,—and on the whole are *sui generis;* and it is proposed to retain for them the aboriginal designation *paha.* 6. There is a large area in the northwestern part of the territory over which the ice melted so slowly that floods were scarcely formed, and over which the ice moved sluggishly in the later stages; and its configuration gives a monotonous plain of low relief, over which rivers and streamlets wander in ill-defined channels of little depth between rounded slopes of boulder-dotted drift.

In this varied topography and in the associated deposits, there is recorded a singularly clear and complete history of the Pleistocene of central United States, which is set forth in detail elsewhere.

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THE PETROLEUM BELT OF TERRE HAUTE. By Prof. C. A. WALDO, Terre Haute, Ind.

[ABSTRACT.]

BRIEF history of oil in Terre Haute.

Brief summary of comparative locations and depths of wells prosecuted to a conclusion.

From the two successful wells and eight failures, an attempt to show the probability of the following conclusions:

1. That oil in the Terre Haute deposit lies above 1280 feet below the level of the Vandalia R. R. at the Union Depot.
2. That the belt is about 1000 feet wide.
3. That the belt is an anticlinal running from one-half a point to a point south of east and north of west.
4. That the rock of this anticlinal is of deep-sea origin.
5. That the strata above lie upon it uncomformably.
6. That the overlying strata are first the Marcellus or Genesee shale and above this the Knobstone group.
7. That the oil rock is Corniferous or Niagara.
8. That the subsequent strata are of shallow water origin.
9. That the direction of the rock conforms to the geology of the locality and its exceptional character.
10. That a series of parallel waves probably exists.
11. That natural gas will probably be found in paying quantities.

SECTION OF THE MAKOQUETA SHALES IN IOWA. By Prof. JOSEPH F. JAMES, Ass't Paleontologist, U. S. Geol. Surv., Washington, D. C.

[ABSTRACT.]

ABSENCE of very certain and definite information, in relation to the Makoqueta shales in Iowa, made it desirable to visit and study the locality where they were exposed. But it was first necessary to find out where the locality was. Inquiry developed the fact that the Post Office Lattners, Dubuque Co., Iowa, was where the shales were exposed, and that this locality was one mile from the station *Graf*, on the Chicago, St. Paul and Kansas City R.R.

The best locality was found along the line of the railroad, where a cut had been made in the rocks, exposing about thirty-one feet of alternating shales and limestones, in the following sequence, from above downwards.

		feet.
No. 18.	Alternating shales and limestones	8
" 17.	Limestone formed of finely comminuted shells, a few perfect	1

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			feet	
No.	16.	Shale in thin laminæ,	1	9′
"	15.	Limestone with Orthoceras, very abundant,	1	
"	14.	Shale, like No. 16,		8′
"	13.	Shale with Orthoceras,		4′
"	12.	Shale,		4′
"	11.	Limestone like No. 15,		5′
"	10.	Shale with Orthoceras, like No. 13,		6′
"	9.	Limestone with Orthoceras like No. 15,	1	
"	8.	Shale with graptolites and small shells,		8′
"	7.	Comminuted shells with Murchisonia,		3′
"	6.	Shale with comminuted fossils, similar to No. 8,		9′
"	5.	Comminuted shells with a few perfect ones—mostly gasteropods,	2	
"	4.	Shale (blue) with graptolites and lingulæ,	3	
"	3.	Shale, with Hyolithes in great abundance,		3′
"	2.	Shale with graptolites, etc., like No. 4,	6	4′
"	1.	Covered, probably shales like No. 2,	3	
		Total,	31°	3′

Certain species of fossils were abundant, among them Orthoceras. It will require study of the material collected to give any details of the organic remains. Graptolites were, in certain beds, found in an excellent state of preservation. In rock above the top of the section as given, are found *Leptæna* and other Brachiopoda, some species being found in chert. The rocks of the series have, probably, a thickness of from 100 to 150 feet.

FIELD STUDIES OF HORNBLENDE SCHIST. By Prof. C. H. HITCHCOCK, Hanover, N. H.

[ABSTRACT.]

REFER to theory of petrographers that this schist is derived from augite rock in some form.

Brief description of a particular range of hornblende schist following Connecticut river at Hanover, N. H., and show that the physical structure of the mass carries out the idea that this band of schist originated in an eruptive diabase.

Shown by disturbances in the strata on both sides and by dikes and altered rocks with contact phenomena.

Age of eruption probably Silurian or post-Cambrian.

Refer to origin of foliation in the hornblende schist. Usually referred to aqueous deposition. Reasons for a different view.

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REMARKS ON THE CRETACEOUS OF NORTHERN MEXICO. By Prof. C. A. WHITE, U. S. Geological Survey, Washington, D. C.

[ABSTRACT.]

IN these remarks the speaker referred to observations made during his late visit to the state of Chihuahua, Mexico, and to the adjacent parts of Texas and New Mexico. A small range of mountains in Chihuahua, seventy-five miles southeastward from Presidio del Norte, known as the Sierra San Carlos, was found to be composed almost wholly of much disturbed, compact, bluish limestone strata having the usual aspect of the Carboniferous limestones of the great interior region. They were found, however, to contain cretaceous fossils from top to bottom, the recognized species being such as characterize the Comanche Cretaceous of Texas. These strata are not less than 4000 feet in thickness, to which must probably be added 500 feet of similar strata at their base which are so much altered as to render their contained fossils undeterminable. All these strata rest with apparent conformity upon 2000 feet of stratified metamorphosed rocks of undetermined age; and the latter rest upon a mountain core of crystalline granitic rock. Upon the top of this series rest with apparent conformity 700 feet in thickness of only slightly altered strata, which contain characteristic fossils of the Colorado Cretaceous group.

The isolated mountain near Presidio del Norte was also found to be composed of the Comanche limestone; and lying upturned against its southern base and extending far to the southward, is a great thickness of shaly strata, succeeded by sandstones, the former bearing fossils of the Colorado Group, and the latter those of the Pierre-Fox Hill Group. The Laramie appears also to be present in that region, and the speaker estimated the total thickness of the Cretaceous seen by him in Chihuahua to be not less than 10.000 feet.

In the Chinate mountains in Texas, about twenty-five miles north of Presidio, the bluish Comanche limestone rests conformably upon carboniferous limestone, the color and character of both being so similar that they are distinguishable only by their respective fossils. Here of course both the Jura and Trias are absent. In both the Chinate and the San Carlos Mountains, the Comanche limestone is silver-bearing at its base.

Cretaceous rocks were observed at several points in Lincoln county, New Mexico, between the Rio Grande and the town of White Oaks, a distance of about eighty miles, but along the greater part of the route Carboniferous rocks only are exposed. No rocks of either Triassic or Jurassic age were observed on this route, the Carboniferous immediately underlying the Cretaceous, when the latter was found to rest upon any clastic rock. No cretaceous rocks were seen here that are thought to be older than the Dakota Group; that is, the Trias, Jura and the Lower Cretaceous all seem to be absent in this part of New Mexico.

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THE PITS AND DOMES OF MAMMOTH CAVE. By Rev. HORACE C. HOVEY, Bridgeport, Conn.

[ABSTRACT.]

THERE are five strongly marked tiers in Mammoth Cave indicating as many periods of cavern history. There are also vertical shafts that cut through all these tiers. These are called pits or domes according to the visitor's point of observation. "Crevice Pit" went by that name for thirty years before it was discovered to be what is now called the Mammoth Dome. Some of these domes have been enlarged into spacious halls. A noble specimen is the "Chief City" said by Bayard Taylor to be "800 feet long, 300 feet broad, and 125 feet high, and to cover between four and five acres." It has just been accurately measured and is 450 feet long and 130 feet wide, and covers one and one-third acres.

Omitting mention of isolated pits, attention is directed now to the region of pits and domes near the one styled "The Bottomless Pit." It is reached by an aperture behind the monolith called the Giant's Coffin. The path leads under the Main Cave. Before getting to the Bottomless Pit we

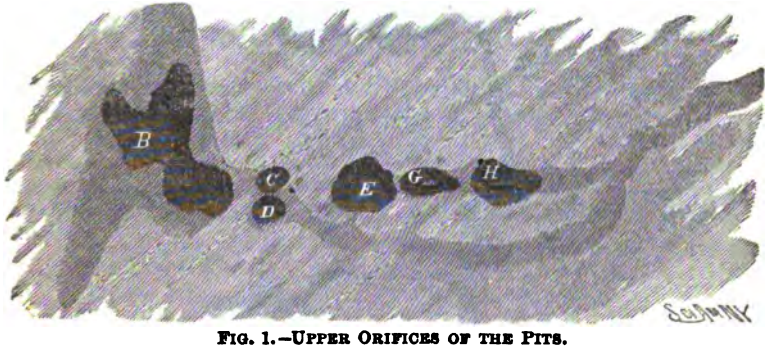

FIG. 1.—UPPER ORIFICES OF THE PITS.

enter a low passage to the left and cross the "Covered Pit" a chasm overlaid by loose slabs of limestone. The writer was the first visitor to cross this and explore what lay beyond. That was ten years ago, and no visitor is known to have crossed since till Mr. Ben Hains did so last April. He also measured the pits. The covered pit is 47 feet deep. One that is provisionally called Pit No. 2 is an oval 10 by 20 feet in diameter. Its first (or false) bottom is 37 feet below the top. Through a hole in this floor the plumb-line went 43 feet before resting, making a total of 80 feet. Pit No. 3 was found to be 80 feet deep beneath a dome equally high. A black spot in the floor attracted the guide's attention who threw a fireball down, and it was afterward measured and 59 feet had to be added to the previous 80 making 89 in all. The pits that I called Scylla and Charybdis in 1879 are separated by a very narrow natural bridge, and Mr. Hains finds them to be in reality parts of one chasm. I measured Scylla by a cord. It is 135

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feet deep. Mr Hains found Charybdis to be but 79 feet deep. Beyond the latter is the edge of the Bottomless Pit that is farthest from where visitors cross by a bridge. Going back to a point near the Fat Man's Misery I followed a narrow crevice by which a point was gained near the bottom of the Bottomless Pit, whence we saw the smoke emitted through an opening into Charybdis. This led me to suspect that all the pits thus singularly clustered together are united with each other. The truth of my conjecture is confirmed by Mr. Hain's recent discoveries. This gentleman, aware of what I had done, made another and a successful attempt to reach the very lowest level. He entered an opening from the room called "Great Relief," and by following for half a mile a tortuous passage emerged into

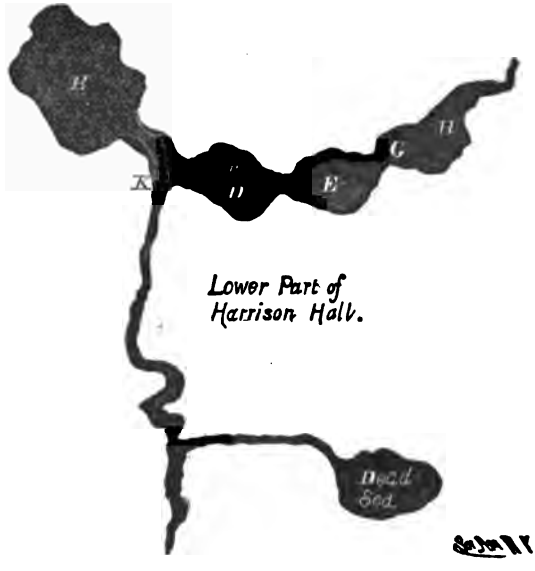

FIG. 2.

Charybdis. He found, as had been surmised, that all these seven or eight pits unite to form a magnificent hall varying in width from 10 to 50 feet, and in height from 35 to 135. The floor is uneven, rising in high and pointed hills between the pits above. It is also very muddy, being full of water in the rainy season which is drained through River Hall. The last part of the long chasm is over a floor of loose rounded fragments of sandstone. Here in the walls were found fossils. The broadest part of the hall is below the Bottomless Pit where it resembles some vast cathedral. The greatest depth of the above pit is 94 feet, 6 inches. Directly under the bridge it is 79 feet. Snowy masses of fungus hang from the bridge. If we add the height of Shelby's Dome and the intervening space we have a

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sum total of 159 feet. We do not consider it as yet proved that Gorin's Dome is joined with the rest; but it is demonstrated that the others form

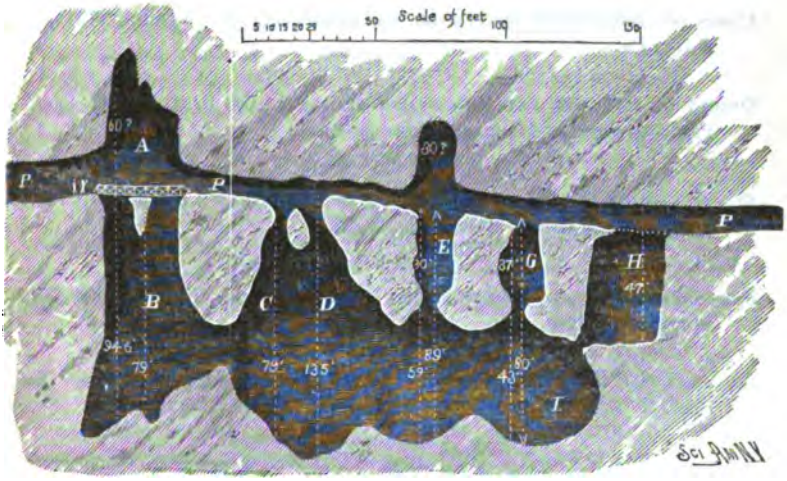

FIG. 3.—VERTICAL SECTION OF HARRISON'S HALL.

an enormous and superb room which we suggest should be called "Harrison's Hall" in honor of the President of the United States.

EXPLANATION TO CUTS.

A, Shelby's Dome; *B*, Bottomless Pit; *C*, Charybdis; *D*, Scylla; *E*, Pit No. 3; *G*, Pit No. 2; *H*, Covered Pit; *I*, Sandstone Debris; *K*, Lower entrance to the Hall; *P*, General Pathway.

TWO NEW FAUNAS FROM THE LOWER CRETACEOUS FORMATION OF TEXAS: (*a*) CAPRINA LIMESTONE FAUNA, (*b*) THE SHOAL CREEK LIMESTONE FAUNA. By R. T. HILL, University of Texas, Austin, Texas.

ON THE ATTRACTIVE SCENERY OF OUR OWN LAND. By Prof. ALBERT S. BICKMORE, American Museum, New York, N. Y.

THE IRONDEQUOIT GLACIER. By CHARLES R. DRYER, Fort Wayne, Ind.

THE MORAINES OF THE WABASH-ERIE REGION. By CHARLES R. DRYER, Fort Wayne, Ind.

THE HISTORY OF THE FORMATION OF THE GREAT LAKES. By Prof. J. S. NEWBERRY, New York, N. Y.

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NOTES ON A KANSAS SALT MINE. By ROBERT HAY, Junction City, Kans.

CASTS OF SCOLITHUS FLATTENED BY PRESSURE. By ATREUS WANNER, York, Pa.

ORIGIN OF BOULDER PAVEMENTS AND FRINGES. By Prof. J. W. SPENCER, University of Georgia, Athens, Ga.

ON THE ORIGIN OF DIAGONAL TRENDS IN THE EARTH'S CRUST. By Prof. DANIEL S. MARTIN, New York, N. Y.

PRESERVATION OF GLACIATED ROCKS IN WORCESTER. By H. T. FULLER, Worcester, Mass.

NATURAL GAS IN FREDONIA, N. Y.; DIMINUTION IN SUPPLY OF GAS. By Prof. H. T. FULLER, Worcester, Mass.

TRAP DIKES IN THE REGION ABOUT LAKE CHAMPLAIN AND THE ADIRONDACKS. By J. F. KEMP, Cornell University, Ithaca, N. Y.

THE MASTODON OF KENT. By EDWARD JONES, Chatham, Ont.

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SECTION F.

BIOLOGY.

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ADDRESS

BY

PROFESSOR GEORGE L. GOODALE,

OF HARVARD UNIVERSITY, CAMBRIDGE, MASS.,

VICE PRESIDENT, BIOLOGICAL SECTION.

SOME RECENT INVESTIGATIONS RELATIVE TO CELL-CONTENTS.

In the Department of Biology, there are three subjects of transcendent interest, namely: protoplasm, or living matter, development and adaptation. In fact the interest in some phases of these subjects is now so general and deep, that the special students in this department feel that they have to a great extent the sympathy and coöperation of the public at large. This interest renders possible the construction of such commodious laboratories as this, the latest acquisition of the University of Toronto, in which we are now permitted to meet. The generous halls and adequate equipment of this laboratory and other biological laboratories throughout our country and Europe, testify to the existence of a wide-spread belief that the New Natural History has much to learn and very much to teach in regard to the great problems of life.

In the annual gatherings of the members of our section, for the exchange of views and for better fellowship, it has been found expedient for us to look at one or the other of these three subjects at the outset of our work, in a somewhat broad and yet special manner.

Your chairman for the present year asks the privilege of selecting as his topic for the introductory address, the first of the subjects mentioned. You are invited to examine the more recent additions to our knowledge of protoplasm, restricting the examination to discoveries in the field of botany.

Whether we consider protoplasm, or the living-matter of plants and animals, from the point of view of physics, of chemistry, of

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physiology or of philosophy, we have before us a topic which has received and which continues to receive the most assiduous attention. Hence its literature, though comparatively recent, is appallingly voluminous, and any attempt to treat the subject, or any considerable part of it exhaustively within the limits properly imposed upon introductory addresses, would result in annoyance to you and utter discomfiture for me. Apropos of this, I am reminded of a series of experiments upon protoplasm, conducted in a German laboratory, which will illustrate the embarrassment which the case presents. The study to which I refer was with regard to certain organisms of very low grade. At a given period in the life of these organisms, their microscopic masses of protoplasm become confluent in such abundance that sufficient material can be procured for experiments on a large scale. In the special investigation referred to, a considerable quantity of protoplasm, obtained in this way, was subjected to enormous pressure. You can anticipate the result; there remained behind only a shrunken residue of what we may call, without figure of speech, the most juiceless and the dryest of husks.

This natural result of extreme compression has stared me in the face during the preparation of the present address. A similar result is more than likely to follow my attempt to bring within very narrow limits the subject which I have chosen for your consideration.

The word protoplasm was coined by Hugo von Mohl in 1846 to designate certain active contents of the vegetable cell. We shall gain in clearness of vision by letting our glance rest first on the results of investigating vegetable cells and cell-contents, anterior to von Mohl's time, in order that we may see some of the steps by which this term was reached by him.

The compound microscope was not applied seriously to the examination of the structure of plants until about fifty years after its discovery by Drebbel. In 1667 Robert Hooke of England published an account of his investigations of minerals, plants and animals under the microscope, and gave excellent illustrations of what he thought he saw. His first reference to the structure of plants is in his description of charcoal, and this is followed by a good account of common cork. In these brief and fairly accurate descriptions, the author makes use of the word "*cell*," applying the term to the cavities in charcoal and in cork.

Hooke's interesting treatise was soon followed by two remarkable

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memoirs, one by an Italian, the other by an Englishman. Malpighi of Bologna sent to the Royal Society of London in 1670 a work entitled *Anatome Plantarum*. The published volumes bear the dates 1675 and 1679. At the period these volumes were in the hands of the Royal Society, Nehemiah Grew, Secretary of the Society, was engaged in work almost identical with that of Malpighi, but there is no good reason to believe, as was formerly intimated, that he was indebted to Malpighi for any of the statements which he published as his own. It is, however, best for us to consider these two works together. By Grew the term "cell" appears to have been applied to the cavities in what we may term the softer tissues of the plant. To him, cells were much like the cells of a honey-comb, and he does not at any time seem to have suspected that cells could be modified into other histological elements.[1] There are, to be sure,

[1] "Next to the *cuticle*, we come to the *Parenchyma* itself, the *part* through which the "*Inner Body*, whereof we shall speak anon, is disseminated; for which reason I call it the "*Parenchyma*. Not that we are so meanly to conceive of it, as if (according to the "stricter sense of that word) it were a meer concreted *Juyce*. For it is a body very cu- "riously *organized*, consisting of an infinite number of extreme small *Bladders*, as in "Tab. 1 is apparent."—*The Anatomy of Plants* by Nehemiah Grew, M. D., 1682, page 4.

"I shall conclude this discourse with a further illustration of the *Texture* of the *Pith*, "and of the whole *Plant*, as consequent thereupon. I say therefore, (and I have given "some account hereof in the *Anatomy of Roots*) that as the *Vessels* of a *Plant*, sc. the *Aer-* "*Vessels* & the *Lymphæducts*. are made up of *Fibres;* according to what I have in this "Discourse above said; so the *Pith* of a *Plant*, or the *Bladders* whereof the *Pith* con- "sists are likewise made up of *Fibres*, which is true also of the *Parenchyma* of the "*Barque*, and also of the *Insertions* in the *Wood*. Yea, and of the *Fruit*, and all other "*Parenchymous Parts* of a *Plant*. I say, that the very *Pulp* of an *Apple*, *Pear*, *Cucumber*, "*Plum*, or any other *Fruit*, is nothing else but a *Ball of most extreme small transparent* "*Threds* or *Fibres*, *all wrapped & stich'd up* (though in divers manners) *together*. And "even all those *Parts* of a *Plant*, which are neither formed into visible *Tubes*, nor into "*Bladders*, are yet made up of *Fibers*. Which, though it be difficult to observe, in any "of those *Parts* which are closer wrought and principally in the *Insertions* of some "*Trees*, yet in the *Pith*, especially of some *Plants*, which consisteth of more open *Work*, "they are more visible, which introduceth the observation of them in all other *Paren-* "*chymous Parts*. so in the Pith of a *Bulrush* of the *common Thistle* & some other "*Plants;* not only the *Threds* of which the *Bladders*, but also the single *Fibers* of "which the *Threds* are composed, may sometimes, with the help of a good *glass*, be "distinctly seen. Yet one of those *Fibres* may reasonably be computed to be a Thou- "sand times smaller than a *Horse-Hair*."

"The *Fibrosity* of the *Parenchyma* is also visible in some *Woods*, in which it is appar- "ently mixed with the *Lignous Parts*, not only by *Insertions*, but *per minimus Partes* "*organicas*. That is to say, the *Parenchymous Fibres*, like smaller *Threds*, are either "*wrapped round about* both the *Lignous & the Aer-Vessels* or at least *interwoven* with them "and with every *Fiber* of every *Vessel;* as in *White Ash* or *Fir-Wood*, with an advanta- "gious posture & light, may be observed.

"Whence it follows that the whole *substance*, or all the *Parts* of a *Plant*, so far as "*Organical*, they also consist of *Fibres*. Of all which *Fibres* those of the *Lymphæducts*, "run only by the *Length* of the *Plant*, those of the *Pith*, *Insertions & Parenchyma* of the "*Barque*, run by the *breadth* or horizontally: those of the *Aer-Vessels* fetch their cir- "cuit by the *Breadth*, and continue it by the *Length*."— *The Anatomy of Plants by Nehemiah Grew*, 1682, pp. 120 & 121.

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a few ambiguous expressions which might indicate that both he and Malpighi held a somewhat different view, but a strict construction of their text compels us to believe that they did not regard the vegetable cell as in any true sense a unit of structure: furthermore it is almost certain that neither Malpighi nor Grew recognized as we can now the multifarious forms of vessels, fibres, long cells and the like, as referable to a common source. There is always a strong temptation to read in an old text some meaning which squares with our own notions, and one is greatly tempted to think that these assiduous investigators, Grew and Malpighi, detected the relationships which we know exist between the different elements of vegetable structure. But after giving them the benefit of every doubt, one fails to find in their writings any recognition of such affinities. On the contrary, these investigators were engaged in a study which naturally led them away from such conceptions: they were busy with descriptive work, outlining the arrangement of tissues in all organs of the plant which their knives could reach. They did not even break up the tissues into elementary parts, but they described and delineated with great skill the tissues as they were displayed in sections. Is it not incredible that these first works on vegetable structure, prepared only a few years after the earliest application

"By which means, the said *Parenchymous Fibres*, in fetching their *horizontal circles*, do "thus *weave*, and make up the *Bladders* of the *Pith* in *Open Work*. And the same *Fibre*, "being thence continued, they also *weave* & make up the *Insertions*, but in *Close-Work*. "Betwixt which *Insertions*, the *Vessels* being likewise transversely interjected, some of "the same *Fibres wrap* themselves also about these; thus *tying* many of them together, "and so making these several *Conjugations* & *Braces* of the *Vessels*, which I have form-"erly described. And as some of these *horizontal Fibres* are *wraped* about the *Vessels*, so "also about the *Fibres* whereof the *Vessels* are composed. By which means it is, that all "the *Fibres* of the *Vessels* are *tacked* or *stitched* up close together into one coherent Piece, "Much after the same manner, as the *Perpendicular Splinters* or *Twigs* of a *Basket* are "by those that run in and out *Horizontally*. And the same *Horizontal Fibres*, being "still further produced into the *Barque*, they there compose the same *work* over again "(only not so *open*) as in the *Pith*.

"So that the most unfeigned & proper resemblance we can at present make of the "whole *Body* of a *Plant*, is to a piece of *fine Bone-Lace*, when the Women are working "it upon the *Cushion*, for the *Pith*, *Insertions* & *Parenchyma* of the *Barque*, are all ex-"tream Fine & Perfect *Lace-Work;* the *Fibres* of the *Pith* running *Horizontally*, as do "the *Threds* in a Piece of *Lace;* and bounding the several *Bladders* of the Pith and *Barque* "as the *Threds* do the several *Holes* of the *Lace*, and making up the *Insertions* without "*Bladders* or with very small ones, as the same *Threds* likewise do the *Close* parts of "the *Lace*, which they call the *Cloth-Work*. And lastly both the *Lignous* and *Aer-Ves-*"*sels* stand all *Perpendicular*, and so cross to the *Horizontal Fibres* of all the said *Pa-*"*renchymous Parts*, even as in a Piece of *Lace* upon the *Cushion*, the *Pins* do to the "*Thred*. The *Pins* being also conceived to be *Tubular* and prolonged to any length "and the same *Lace Work* to be wrought many Thousands of times over & over again "to any thickness or hight according to the hight of any *Plant*. And this is the true *Text-*"*ure* of a *Plant* and the *general composure* not only of a *Branch*, but of all other parts "from the *seed* to the *seed*.— *The Anatomy of Plants, by Nehemiah Grew*, 1682, p. 121.

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of the compound microscope to the study of plants, should have remained for almost one hundred and fifty years the only comprehensive treatises on the subject? But the most charitable inquirer fails to find during that long period any other works of importance on vegetable anatomy.

Near the close of the last century, at a period characterized by activity in many departments of speculative inquiries, the subject of vegetable structure again excited considerable attention, but little substantial advance was made. In 1804, the Royal Society of Sciences at Göttingen[1] proposed for competition, certain questions relative to the structure and the mode of growth of tissues. The chief contestants for this prize were Link, Rudolphi, and Treviranus. The memoirs of the first two received prizes, that of the latter, honorable mention. The names of others should be referred to as having worked at or about this time, in the same field, namely, Bernhardi, Mirbel and Moldenhawer, the latter making a great advance in certain directions. But to all of these whom I have mentioned, including the winners of the prize, the important questions seemed to be, how are the structural elements distributed, rather than how they are related to each other in manner of growth and as respects their origin. With the cell-contents they had comparatively little to do; they were busy with the constituents of the framework.

There seems to have been a strong suspicion on the part of some botanists during that period, that all this study of the skeleton of the plant failed to go to the bottom of the question. The only wonder is that with their scanty and untrustworthy chemical appliances and with their very imperfect lenses they accomplished so much. May I remind you that the element iodine which is the most important reagent in the examination of the contents of vegetable cells was not employed until the year 1812; and, further, that no good achromatic and aplanatic lenses, of even moderately high power, were constructed until 1826.[2]

Noting the more important discoveries of the next period in their order, we come first upon that of the nucleus of vegetable cells by Robert Brown in 1833, and one mode of cell-division by Mohl in 1835. In 1838 the eccentric Schleiden published his contributions to Phytogenesis in which he states substantially that

[1] Königliche Gesellschaft der Wissenschaften zu Göttingen.

[2] Æpinus and Van Deyl had nearly succeeded more than twenty years earlier.

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cells of plants can be formed only in a fluid containing as chief ingredients, sugar and mucus ("schleim"). By this latter term he designated the nitrogenous matters taken collectively. At his touch all disguises fell, and for the first time the vegetable cell was distinctly recognized as a unit of structure always serving as the common basis for the formation of the innumerable shapes of the structural elements.

Next comes the master, Mohl. Armed with the best optical appliances procurable, familiar with the use of the chemical reagents then at command, and accustomed to accurate research, he reviews his own earlier work and that of his contemporaries, making rapid advances in the knowledge of the contents of the cell. In 1844 in a paper on the circulation within vegetable cells, he speaks of the living mass in each active cell, and distinctly recognizes it as that which is the treasury of stored energy and the vehicle of energy under release. He describes it as that which builds shapely forms out of unformed matter and at first hands. This substance he names *protoplasma*.[1]

If we look at the handbooks of botany just before this date of the early forties, we find references to "coagulable" matters (Treviranus) and the like. The chemical instability of the substance within cells was suspected of having much to do with its activity, but almost all of the notes, as well as those upon the same subject found here and there in philosophical writings of the latter part of the last century, are based on pure speculation. The scientific recognition of a physical basis of vital activity must be credited to Schleiden and Mohl.

The term protoplasm was at once adopted by Schleiden as a good substitute for the indefinite and misleading word *schleim* which he had employed to designate essentially the same substance, and it became thoroughly established in scientific terminology. In 1850, Professor Cohn (and Unger in 1855) showed that the protoplasm of vegetable cells is identical with what had been described

[1] "Da wie schon bemerkt diese zähe Flüssigkeit uberall, wo Zellen entstehen sollen, den ersten, die künftigen Zellen andeutenden festen Bildungen vorausgeht, da wir ferner annehmen müssen dass dieselbe das Material fur die Bildung des Nucleus und des Primordialschlauches liefert, indem diese nicht nur in der nächsten räumlichen Verbindung mit derselben stehen, sondern auch auf Jod auf analoge Weise reagiren, das also ihre Organisation der Process ist, welcher die Entstehung der neuen Zelle einleitet, so mag es wohl gerechtfertigt sein, wenn ich zur Bezeichnung dieser Substanz eine auf diese physiologische Function sich beziehende Benennung in dem Worte Protoplasma vorschlüge."—*Bot. Zeit., 1846*, p. 75.

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in 1835, in animal structures, as *sarcode*, by Dujardin, and this prepared the way for the exhaustive treatise by Max Schultze in 1858. From that date on, work in the contiguous fields of botany and zoölogy has made no physical or chemical distinction between the living-matter in animals and plants. Investigators in the two fields have been mutually helpful.

Mohl, in his treatise on the vegetable cell, published in 1851,[1] gives the following account of protoplasm.

"If a tissue composed of young cells be left some time in alcohol, or treated with nitric or muriatic acid, a very thin, finely granular membrane becomes detached from the inside of the walls of the cells, in the form of a closed vesicle, which becomes more or less contracted, and consequently removes all the contents of the cell, which are enclosed in this vesicle, from the wall of the cell. Reasons hereafter to be discussed have led me to call this inner cell the *primordial utricle* (*primordialschlauch*). . . . .

"In the centre of the young cell with rare exceptions rises the so-called *nucleus cellulæ* of Robert Brown ("Zellen-kern;" "Cytoblast" of Schleiden). . . . . .

"The remainder of the cell is more or less densely filled with an opaque, viscid fluid of a white color, having granules intermingled in it, which fluid I call *protoplasm*."

We must now pass without notice numerous contributions to the subject made about this time, and consider Hofmeister's description of protoplasm given in his Vegetable Cell, published in 1867.

"The substance Protoplasm, whose peculiar behavior initiates all new development, is everywhere an essentially homogeneous body. It is a viscid fluid, containing much water, having parts easily motile, capable of swelling, and possessing in a remarkable degree the properties of a colloid. It is a mixture of different organic matters among which albuminoids and members of the dextrine group are always present. It has the consistence of a more or less thick mucus and is not miscible with water to any great extent."

From these and other accounts of the same date, we see that the following points were regarded as established:— (1) All of the activities of the vegetable cell are manifested in its protoplasmic contents. (2) Protoplasm consists chemically of a nitrogenous

[1] The English translation in 1852.

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basis. (3) Protoplasm has no demonstrable structure. (4) The protoplasmic contents in one vegetable cell are not connected with the protoplasmic contents in adjoining cells. (5) The nucleus and other vitalized granules in the vegetable cell are formed by differentiation from amorphous protoplasm.

It is now our duty to see in what manner these views have been modified during the last twenty or rather ten years. In describing the changes of opinion, time will not suffice for us to allude to most of the observers; a few only can be mentioned by name.

The first thesis, namely, that all of the activities of the vegetable cell are manifested in its protoplasmic contents, may be regarded as firmly established. It is at this point in our present examination when, if we had time, we should take up, one by one, the terms which have been applied to some specialized or localized parts of what Mohl and Hofmeister knew as protoplasm. We can only glance at them in passing:—thus *cytoplasma* is understood to be the mass exclusive of the granular contents of all kinds; *hyaloplasma* is the outer hyaline layer; *polioplasma* is the grayish granular part. To these terms may be added others, such as *paraplasma*, etc.

The second thesis, viz.:—protoplasm consists chemically of a nitrogenous basis, remains unchanged. But instead of regarding the protoplasmic basis as simple or one, it is now known to be exceedingly complex, and to contain numerous allied proteids, some of which can be identified in the basic mass, others in the nucleus and others still in the vitalized granules.

Researches respecting this thesis must be considered also with reference to work by two diligent investigators, Pfeffer and de Vries. The former has shown the conditions under which active protoplasm reacts in the presence of certain chemical excitants; the latter has demonstrated the relations of a part of this irritability of protoplasm to its physical constitution. But as a result of all these recent studies it becomes more and more clear that the chemical relations of the protoplasmic activities are still veiled in mystery. Botanists are receding from a position held by many only a few years ago, namely, that it is safe to use the words albuminoids and protoplasm interchangeably. Nowadays the latter term is generally restricted to morphological and physiological conceptions; the former keeps its wide chemical significance.

Just here, come also the chemical studies of protoplasm; by

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Rodewald and Reinke on a large scale, by Loew and Bokorny, and by Schwarz under the microscope. All of these results compel us to recognize in protoplasm a substance of bewildering complexity of composition and constitution. Moreover, you all know how wide this field of research has suddenly become by the discovery that different microbes (which are essentially minutest masses of protoplasm) not only give rise to such diverse products, but present such diverse chemical reactions.

Protoplasm is no longer regarded by any one in any sense as a comparatively simple substance.

The third thesis, namely, that protoplasm has no demonstrable structure, has been modified in a striking manner as a result of improved appliances for research. By better methods of staining and by the use of homogeneous immersion objectives the apparently structureless mass is seen to be made up of parts which are easily distinguishable. There has been, and in fact is now, a suspicion that some of these appearances under the influence of staining agents are post-mortem changes and do not belong to protoplasm in a living state. But it seems to be beyond reasonable doubt that protoplasm is marvellously complex in its morphological and physical as well as its chemical constitution. One statement of the case is as follows:—

Under ordinary circumstances, protoplasm is composed of a mesh of inconceivable fineness, in which mesh are entangled the more liquid interfilar portions (paraplasma); so that the dry husks left in Reinke's experiment may be regarded in fact as the residue of network from which all the moisture has been expelled. But this conception of protoplasm as a mass composed of a network of minutest fibres enclosing in its meshes another substance presents, as has been well shown by some critics, great difficulties, especially when we endeavor to explain the movements within the cell. It is also very difficult to explain in any way the so-called wandering of protoplasm outside the cell wall or into intercellular spaces.

Fourth, we are to glance at the accepted statement that the protoplasmic body or protoplast, as it is called, of one cell is cut off by the cell wall from all connection with the contiguous cells. There are a few cases in which this intervening wall was formerly held to be pervious, but such cases were considered as exceptional. Now, however, as has been shown by Gardiner and others who have followed out his exact researches, there are intercommunicating

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threads of protoplasm of extreme fineness between adjoining cells, and these living threads maintain a connection, sometimes direct, sometimes indirect, between one protoplasmic mass and another. This has been shown to be so widely true in the case of the plants hitherto investigated, that the generalization has been ventured on, that *all the protoplasm throughout the plant is continuous*. The formation of the dividing wall in cell division is now better understood than ever before, and our knowledge of this process lends great probability to the truth of the general statement made. It is not unlikely then that all the living matter throughout each plant is continuous, a whole, shut off only partially until the time of severing from the mother plant from the body of protoplasm there, and thus making a true chain of descent.

May I ask you to observe, in passing, how this bears on the vexed subject of individuality of plants. Brücke in 1862 declared that the living protoplasmic contents of a cell formed an elementary organism, and this idea found its fullest expression in the profound work by Hanstein in 1880. In that treatise Hanstein proposed, for the living protoplasmic contents of the cell, the term protoplast, in order to indicate its individuality. But these late researches show that these protoplasts are not only highly organized and of complicated structure, but each is bound by indissoluble ties to its nearest neighbors, each helping to form a united whole.

The fifth thesis has been completely controverted. Instead of believing as formerly that all the granules within the cell arise *de novo* from the protoplasm in which they are embedded, we are now forced to regard all of them as springing from preëxistent bodies of the same character.

Hofmeister in 1867, in an exhaustive description of the contents of vegetable cells, states distinctly that the nucleus arises from homogeneous protoplasm, and that in all cell division the nucleus must first disappear, two new ones arising in its place. The nucleus, according to him, occupied a secondary place as a derivative organ, and the chlorophyll granules were believed by him and his contemporaries to be new formations from homogeneous protoplasm under certain conditions of light, temperature and food. Researches which leave no room for doubt have shown that the nucleus, in all cases hitherto examined, springs from a preëxistent nucleus by a process of division. The process of division with its marvellous

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sequence of formal arrangements of definite portions in meridional lines and in polar and equatorial masses, has been most carefully examined in almost every organ of the plant, and in connection with similar processes of cell-division in animal tissues. In no well marked case has a nucleus been observed to arise from homogeneous protoplasm, even a few doubtful instances having been lately explained satisfactorily.

The extraordinary manner in which the nucleus, both in common cell-division and in reproductive blending, carries ancestral characters and controls the distribution of nutritive materials, is as yet the greatest mystery in vegetable life.

We pass next to consider a very important change of view in regard to the other granules embedded in the protoplasmic body, known as leaf-green or chlorophyll granules. Formerly, as we have noticed, it was held that all of these sprang by a process of differentiation from the shapeless mass in each exposed cell. Researches by Schmitz on some of the lower plants, and by Schimper and Meyer on the higher, have shown that these chlorophyll granules always arise by a process of division from preëxistent granules. This fact taken by itself might not possess great interest. It is, however, known that at the growing points where leaves are developed, the cells contain in their protoplasm, granules of about the consistence and color of protoplasm itself, and these granules have the power of division, much after the fashion of the cell nucleus. But the products of such division are essentially three-fold: some of the resulting granules are colorless, like the mother granules; others become true chlorophyll-granules, while others still, in those leaves which become the leaves of the flowers and the fruit, assume colors other than green. In other words we have in these associated granules, or chromatophores, a morphology which is of the highest interest. The needs of the plant bring from this common source the microscopic organs for assimilation, for storing up starch in the form of grains, for protection and attraction. This most interesting generalization, in regard to the granules taken together, adds a new zest to the study of the developing plant and the evolving species.

It has been lately claimed by de Vries of Holland, that the sap-cavities or vacuoles in protoplasm divide in much the same way as do the granules just referred to, but this part of the subject is not yet beyond all doubt. That the sap-cavities are the birth-place of

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most crystals, and that the aleurone grains are desiccated sap-cavities has been made out by several observers. But it is not clear that vacuoles divide as granules do.

What we do know beyond all reasonable question is this,— that all the working granules within the plant have sprung from pre-existent granules, and that there is no break here in the transmission from parent to offspring.

Such then are some of the more important changes which have taken place with regard to our knowledge of the living contents of vegetable cells. I would gladly take the time, if it could be granted, to call your attention to certain most interesting discoveries which have been made by Pfeffer relative to the absorption of coloring agents by living protoplasm, and which have been supplemented by Campbell in regard to the nucleus. But more than this allusion is now impossible.

It is an interesting coincidence that with the substituting of the crude compound microscope for high power simple lenses about 1660, came the first works on vegetable structure, and for more than one hundred years, or until the introduction of achromatic object glasses, these works were in truth the only authoritative treatises. With the introduction of water-immersion lenses came renewed activity in this field, and with the later discovery of homogeneous immersion lenses came the results which have now been detailed. Whether we have, at these stages, more than a series of interesting and very striking coincidences, or not, we have not time now to discuss. It is enough for our present purpose to observe that, with the introduction of the cedar-oil immersion objectives, a thorough reïnvestigation of certain parts of this subject began. One may be pardoned for asking whether the objectives known as apochromatics are to open up in this field new lines of research.

Can these recent discoveries relative to the continuity of protoplasm and the genetic relationship of the associated granules (including in the widest sense, the nucleus) be made to cast any light on the question of development, as they certainly do upon the kindred question of adaptation? The answer has been given us very lately by Hugo de Vries of Amsterdam.[1] This investigator, who has done very much to clear up certain obscurities in regard to the external relations of the cell, has recently revised the

[1] Intracellulare Pangenesis, Jena, 1889.

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neglected doctrine of pangenesis and applied it to the question just propounded. De Vries suggests that we divide the hypothesis of pangenesis as proposed by Darwin into two parts, as follows: (1) In every germ-cell individual characters of the whole organism are represented by material particles which, by their multiplication, transmit to descendants all of such peculiarities. (2) All the cells of the organism throw off at certain periods of development material particles which flow towards the germ-cells supplying its deficiencies.

Now, de Vries asks, whether it is not high time for us to look at the first part of this hypothesis again and abandon the hindrances which the latter part imposes. If we accept his suggestion and restate the hypothesis, in view of what has been learned relative to the nucleus and other granules (the trophoplasts) within the cell, we should then read:

In every cell at a growing part are all the elements ready for multiplication. Each protoplast possesses the organs necessary for continuous transmission: the nucleus, for new nuclei; the trophoplasts for new granules of all kinds according to the needs of the plant.

De Vries reviews all theories bearing on the question, from the so-called plastidules of Elsberg to the germ-plasma of Weismann, and then applies his hypothesis of intra-cellular pangenesis to the different parts of a single plant and to the transmission of peculiarities. The active particles recognized in Darwin's hypothesis, he terms *pangens*, and, regarding them as vehicles of hereditary characters, traces them throughout their course. He is not obliged to ask for any means of transportation for these pangens, since they work, so to speak, on the spot. They are ready at hand at the points of growth.

We must look very sharply with reference to this at two points of growth in the flowering plant, namely, the bud and the seed. Each bud with its growing point, made up of cells containing in their protoplasm the divisible granules, carries with itself all the peculiarities which have been transmitted without appreciable change. In the formation of the bud there is fission, but no blending. The cells divide, and each in turn may divide until the ultimate form of the leafy branch or flower is reached. In the leafy branch new buds form, and in their turn carry forward the ancestral peculiarities. But in the flower on the other hand, with the

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formation of the ovule, all development is arrested (except in the rare cases of parthenogenesis and the like) unless the protoplasm of the embryonal sac receives a new impetus from material contributed by the pollen grain. And in this blending of parts which have developed under different external conditions, we see that there is a chance for variation to come in. Not only is there a blending of the nuclei but a sharing of the accompanying trophoplasts. How this can be applied to the lower plants and other organisms cannot now be referred to. It would not be right to hold de Vries wholly responsible for the application just given, but I ask you whether the hypothesis does not appear fruitful. It certainly seems, to me, to be likely to stimulate speculation and research in this important field.

In view of de Vries' work and of the results of recent study which I have endeavored to bring before you this afternoon, does not the following statement of Darwin possess new force?

"An organic being is a microcosm, a little universe, formed of a host of self propagating organisms, inconceivably minute and as numerous as the stars in Heaven."

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PAPERS READ.

THE PALÆONTOLOGICAL EVIDENCE FOR THE TRANSMISSION OF ACQUIRED CHARACTERS. By Prof. HENRY FAIRFIELD OSBORN, Princeton, N. J.

As a contribution to the present discussion upon the inheritance of acquired characters I offer an outline of the opinions prevailing among American naturalists of the so-called Neo-Lamarckian school, and especially desire to direct attention to the character of the evidence for these opinions. This evidence is of a different order from that discussed in Weissmann's essays upon Heredity, and while it cannot be said to conclusively demonstrate the truth of the Lamarckian principle, it certainly admits of no other interpretation at present, and lends the support of direct observation to some of the weightiest theoretical difficulties in the pure selection principle.

1. We regard natural selection as a universal principle, explaining the "survival of the fittest" individuals and natural groups, and as the only explanation which can be offered of the origin of one large class of useful and adaptive characters. We supplement this by the Lamarckian principle as explaining the "origin of the fittest" in so far as fitness includes those race variations which correspond to the modifications in the individual springing from internal reactions to the influences of environment. There is naturally a diversity of opinion as to how far each of these principles is operative, not that they conflict.

2. If both principles operate upon the origin of the fittest we should find in every individual two classes of variation, both in respect to new characters and to modifications of the old: first, chance variations, or those which, with Darwin and Weissmann, we attribute to the mixture of two diverse hereditary strains; these may or may not be useful; if useful they depend entirely upon selection for their preservation. Second, variations which follow from their incipient stages a certain definite direction towards adaptation; these are not useful at the start; thus while, as they accumulate, they favor the individual, they are not directly dependent upon selection for their preservation; these we attribute to the Lamarckian principle.

My present purpose is to show that variations of the second class are of an extent and importance not suspected previous to our recent palæontological discoveries, and that the Lamarckian principle offers the only adequate explanation for them.

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3. The general theory as to the introduction and transmission of variations of the second class may be stated as based upon the data of palæontology — the evolution of the skeleton and teeth.

(1) In the life of the individual, adaptation is increased by local and general metatrophic changes, of necessity correlated, which take place most rapidly in the regions of least perfect adaptation since here the reactions are greatest. (2) The main trend of variation is determined not by the transmission of the full adaptive modifications themselves, as Lamarck supposed, but of the disposition to adaptive atrophy or hypertrophy at certain points. (3) The variations thus arising are accumulated by the selection of the individuals in which they are most marked and by the extinction of inadaptive natural groups. Selection, in so far as it affects these variations, is not of single characters but of the *ensemble* of characters.

The evidence is of a direct and indirect character. The direct evidence is that by actual observation in complete palæontological series, the origin of adaptive structures is found to conform strictly to the lines of use and disuse. The indirect proof is that the natural selection of chance variations is unsupported by observation and is inadequate to explain the variation phenomena of the second class.

4. I will first briefly consider the former. The distinctive feature of palæontological evidence is that it covers the entire pedigree of variations, the rise of useful structures not only from their minute, apparently useless condition, but from the period before they appear. The teeth of the mammalia render us the most direct service, as compared with the feet, since they furnish not only the most interesting correlations and readjustments, but the successive addition of new elements. With a few exceptions which need not be noted here, all the mammalia started with teeth of the simple conical type — like the simple cusps of reptiles. Practically every stage between this single cusp and the elaborate multicusped recent molar is now known. Every one of the six main cusps of the molar of *Hyracotherium*, for example, a type of an important central stage in the ungulate dentition is first indicated at the first point of contact or extreme wear between the upper and lower molars; this point of wear is replaced by a minute tubercle, which grows into a prominent cusp. These are the laws of cusp development, as observed in every known phylum of mammalia:

(1) The primary cusps first appear as cuspules, or minute cones, at the first points of contact between the upper and lower molars in the vertical motions of the jaw.

(2) The modelling of cusps into new forms, and the acquisition of secondary position, is a concomitant of interference in the horizontal motions of the jaws.

5. The evidence, of which this is only a single illustration, has accumulated very slowly. The line of reasoning from this particular series of observations is as follows: (1) The new main variations, in the teeth and skeleton of every complete series, are observed to follow certain definite purposive lines. (2) By careful analysis of the reactions to environment which would occur in the individuals by the laws of growth— we observe

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that the race variations strictly conform to the lines of these reactions. (3) We further observe that no variations of this class occur without the antecedent operation of these reactions; the working hypothesis thus stands the test of prediction. (4) We accept this invariable sequence of race adaptation upon individual adaptation as proof of a causal relationship.

6. I admit that this proof may be invalidated in several ways: (1) By showing in more extended research that these observations of sequence are inaccurate or offset by others in which there is no such sequence. (2) By showing that the Lamarckian principle, while explaining some of the variations of this class, is directly contradictory to others. (3) By showing that all these phenomena may be explained equally well or better by Natural Selection. (4) By proving independently, that the transmission of acquired characters never occurs.

I will now consider each of these cases:

First — as regards these observations. They may be examined in detail in the studies of Cope, Wortman or Ryder, and in a paper I presented to this Association last year. As the question of transmission has been generally assumed in the foregoing studies, I think it is now important to review the whole field, searching for facts which look against the Lamarckian principle, for as we have been hitherto studying with a *bias* in favor of it, some such adverse points may have been overlooked. At present, however, I can recall only a single adverse observation, that is, in the development of one of the upper cusps, the lower cusp which opposes it, and which is therefore supposed to stimulate this development is found to recede. I have no doubt others will be found presenting similar difficulties.

Second — as regards the Lamarckian principle. Several objections to the special application of this principle to the evolution of the teeth have been raised by Mr. E. B. Poulton:

A.—To the objection that the teeth are entirely formed before piercing the gum and that use produces an actual loss of tissue as contrasted with the growth of bone, it may be said that by our theory, it is not the growth itself but the reactions which produce this growth in the living tissue, which we suppose to be transmitted.

B.—To the objection that this proves too much, that the cusps thus formed would keep on growing, it may be said (*a*) that in the organism itself these reactions occur least in the best adapted structures. This proposition is difficult to demonstrate in the case of the teeth, but may be readily demonstrated in what are known as the phenomena of displacement in the carpals and tarsals where growth has a direct ratio to impact and strain. (*b*) In the organism itself growth does not take place beyond the limits of adaptation, there is, therefore, no ground for the supposition that overgrowth will take place by transmission. (*c*) Either by the Selection or Lamarckian theory development is held in check by competition between the parts; there is a limit to the nutritive supply; in the teeth, as elsewhere, the hypertrophy of one part necessitates atrophy of another.

C.—A general objection of considerable force is that we find other adaptations, equally perfect, in which the Lamarckian principle does not apply;

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why then invoke it here? To this it may be said that there is no theoretical difficulty in supposing that while natural selection is operating directly upon variations of the first class, the Lamarckian principle is producing variations of the second class, and while selection does explain the former, it falls far short of explaining the latter.

D.—Finally, if Weissmann succeeds in invalidating the supposed proofs of the Lamarckian principle derived from pathology and mutilations, this will not affect the argument from palæontology and comparative anatomy, for these proofs involve two elements which are not in our theorem: (*a*) immediate transmission of characters; (*b*) transmission of characters impressed upon the organism and not self-acquired.

Third—as regards the adequacy of the selection principle to explain these variation phenomena. It is not necessary to repeat here the well-known current theoretical objections to this principle, but simply to point out the bearing of this palæontological evidence. In Weissmann's variation theory the preponderating influence must be conservative, however it may explain progressive modification, or even correlation of old characters, it does not admit that the genesis of new characters should follow definite lines of adaptation which are not pre-existent in the germ plasma. We find that new characters of the second class do follow such purposive or directive lines, arising simultaneously in all parts of the organism, and first appearing in such minute form that we have no reason to suppose that they can be acted upon by selection. The old view of nature's choice between two single characters, one adaptive, the other not adaptive, must be abandoned, since the latter do not exist in the second class.

Fourth—the most serious obstacle to the Lamarckian principle is the problem of transmission. How can peripheral influences be transmitted in the way we have outlined — now that we have such strong evidence for the continuity of the germ plasma? If acquired characters are not transmitted it is clear that the whole Lamarckian principle is undermined, and all these instances of sequence express no causal relationship. We are then, however, left without any adequate explanation of the laws of variations of the second class, and are thus driven to postulate some third, as yet unknown, factor in evolution to replace the Lamarckian principle.

PRELIMINARY REPORT ON REPRODUCTIVE ELEMENTS OF EUDENDRIUM.

By Prof. CHAS. W. HARGITT, Oxford, Ohio.

[ABSTRACT.]

EUDENDRIUM, as is well known to zoölogists, constitutes one of the genera of Cœlenterata, popularly known as hydroids. During the summer of 1887 while working in the marine laboratory under direction of Dr. H. W. Conn, I undertook, at his suggestion, a study of the genus named at the head of this paper, with special reference to the origin of the repro-

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ductive elements, and also the mode of their development. This genus had been studied some years previous by Kleinenberg and Weissmann and later by De Verenne. These authors had arrived at quite different conclusions especially as to the origin of the germ cells.

As has been well known for some time from the work of Kleinenberg and others the ova of common hydra are very amœbiform. This characteristic has also been noted in Eudendrium, and has been referred to the importance of securing ample nutrition and finally to location in the gonophores.

From these facts Kleinenberg was led to the conception of the origin of the cells in the ectoderm, and this conclusion was likewise corroborated by the work of Weissmann.

My own studies incline me to a very different conclusion, namely, that the reproductive elements have their origin in the endodermal tissues. This conclusion was arrived at with no knowledge of the paper by De Verenne above mentioned, and in which he contends for the same origin. I was therefore the more particular in locating these elements, and yet submit my conclusions in the most tentative way, in view of the exceeding liability to incorrectly interpret facts observed in this very variable group, and to the exceeding minuteness of the primitive cells, and the aforementioned amœbiform characteristic.

In reference to the segmentation of the ova I was only able to find delamination as the mode by which the primitive or germ layers arise. The planula is quite like this stage in other members of this and kindred genera.

ALIMENTARY APPARATUS OF THE HONEY BEE, APIS MELIFICA. By Prof. A. J. COOK, Agricultural College, Mich.

[ABSTRACT.]

THIS paper describes (with illustrations) the anatomy and physiology of the bee's tongue, the three pairs of salivary glands, the stomach mouth and the true stomach. The nature of the special aliment of the queen, drones and larval bees is explained, and proof offered to sustain the opinion.

A NEWLY IMPORTED ELM INSECT. By L. O. HOWARD, Department of Agriculture, Washington, D. C.

[ABSTRACT.]

AN old and well-known European bark-louse (*Gossyparia ulmi* Geoffroy) has recently been imported into the United States in four distinct localities on different species of European elms. It has spread in two of these localities — Washington and Boston — to the native elms, and promises to become a serious pest. The author gives the life-history of the species at length.

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SOME PECULIARITIES OF ANTENNAL STRUCTURE IN THE DELTOIDS. By Prof. JOHN B. SMITH, Rutgers College, New Brunswick, N. J.

[ABSTRACT.]

No noctuid group has so many structural peculiarities as that usually called *Deltoidæ*, and which cannot yet be satisfactorily separated from the *Noctuidæ*. The aborted structures of the forelegs of the males of many of the species have been described and figured by me: the peculiar antennal characters have not yet been published. The males in many of the genera have the antennæ more or less pectinated, serrate or ciliate in a manner not unlike some others of the noctuid genera. In *Philometra longilabris* the pectinations are excessively long and feathery. In the congeneric *P. serraticornis* occurs a tendency not heretofore noted—the appendages or branches of each joint are not symmetrical, *i.e.*, the pectinations are not opposite, as they are in every other species that I have examined, but are alternate and unequal; a short branch issuing from the base at one side and a long branch from the apex of the joint at the other; it is less unusual to find the branches unequal in length but yet opposite. A more interesting peculiarity is a modification at about the middle of the antennæ of the males, at the outer side, and which is supposed to be used by the male in clasping the antennæ of the female when in copulation.

In its simplest form it occurs in *Chytolita* or *Herminia*, where two of the joints have long corneous outward processes so arranged that by bending the antenna the processes are approximated so as to hold tightly anything clasped between them. In *Zanclognatha* there are three processes and three joints are involved in the modification. The central process is longest, stoutest and straight: the others are more slender, shorter and lean somewhat toward the central process. In *Megachyta*, a somewhat modified form is noted; here three joints are moniliform, and each joint has an outer short, curved, acute process. The hold here is between the antennal joints, the curved processes acting as outer ring of the band. A very much more complicated arrangement is seen in *Litognatha*, which also has the most remarkably aborted forelegs. Here five joints are involved: the first shortened, and with a little outer process; the second is distorted, a little inwardly set so as to leave a little groove outwardly; the central joint is much the larger, both broader and longer, a little *outwardly* set, with two downward corneous processes and a modification of the ordinary pectination above them; the fourth joint is simply shorter, with an outer branch only; the fifth almost normal, lacking only the outer branch of the normal pectination.

Renia has a type quite different from all the others. Here the modification is confined to two joints, but a joint below has a large tuft of hair which hides the modification and has prevented its recognition heretofore. The lower modified joint has a long upward prolongation, reaching nearly to the apex of the second modified joint. This is very much longer than any other of the antennal joints, curving inwardly so as to form a clasp between it and the upper prolongation of the lower modified joint.

Similar characters seem to occur in some Pyralid families, but no such distinctive features intended as clasping organs have been noted.

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THE HORN FLY: HÆMATOBIA CORNICOLA WILL. By Prof. JOHN B. SMITH, New Brunswick, N. J.

[ABSTRACT.]

FOR two years past a fly theretofore unknown has been exciting considerable alarm among farmers. It has the rather unusual habit of congregating on the horns of cattle, and the wildest stories as to its injuries to stock were soon afloat. I have worked out the complete life-history of the fly which offers several interesting characters. The habit of spreading its wings when feeding, the fact that they remain on the cattle almost constantly, and finally their habit of clustering on the horns of the cattle when at rest, sometimes in very large numbers, are unusual. They oviposit at night and the eggs are unusually large, and laid in fresh cow dung. The entire life-history is comprised in twelve to fourteen days of which five or six are comprised in the pupa state. Numerous broods thus appear in a single season. The injury to cattle is principally seen in a decided falling off in milk and cream and in the poor condition of the steers and other butcher cattle. They never in any way injure the horns by eating or otherwise.

ON THE INTENTIONAL IMPORTATION OF PARASITES AND NATURAL ENEMIES OF INSECTS INJURIOUS TO VEGETATION. By C. V. RILEY, Ph.D., U. S. Dept. of Agriculture, Washington, D. C.

[ABSTRACT.]

THE author discusses the importance of the subject of his paper and mentions several instances in which parasites have been carried from one portion of a country to another portion of the same country in which they did not previously exist. He details also the introduction of *Microgaster glomeratus*, one of the commonest parasites of the European cabbage butterfly, from Europe into this country in 1885; but devotes the greater part of his paper to a consideration of the facts connected with the importation of the parasites and natural enemies of the fluted scale (*Icerya purchasi* Maskell) from Australia into California during the winter of 1888–9, showing that the fluted scale is an indigene of Australia in which country it does little or no damage on account of its natural enemies. This importation of parasites and predaceous insects was made by the author and his official assistants and the anticipated success is already more than assured, one of the imported species (*Vedolia cardinalis*) spreading very rapidly and cleaning out the Icerya wherever it spreads.

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A BACTERIAL DISEASE OF INDIAN CORN. By Prof. T. J. BURRILL, Champaign, Ill.

[ABSTRACT.]

THE first observations upon this disease were first made by the writer in 1882, but the disease has not been fully worked out until the present season. The produce of the fields is sometimes seriously reduced by this hitherto unrecognized disease. The appearance of the affected plants and fields was described and the specific characteristics of the bacteria given. The paper is published in the transactions, for 1889, of the society for the promotion of agricultural science, and in a bulletin of the agricultural experimentation station of the University of Illinois.

A BACTERIAL DISEASE OF CARNATIONS. By Prof. J. C. ARTHUR, La Fayette, Ind.

[ABSTRACT.]

NOTES the recent discovery of a very general disease of the carnation. The earliest indication of its presence in the plant is the appearance of transparent dots in the leaves, only to be seen by transmitted light. These spots increase and coalesce, and kill the tissues, at last the leaves dry up and the plants gradually die. Microscopic examination shows the transparent spots to be due to engorgement of the cells with bacteria. Cultures of the bacteria have been made, and the disease produced in healthy plants by applying the bacteria from a fluid culture to the surface of the leaves.

NOTES ON SEEDLINGS OF ELYMUS VIRGINICUS. By Prof. W. J. BEAL, Agricultural College, Mich.

[ABSTRACT.]

FOUR hundred seedlings of non-glaucous plants were all non-glaucous; of four hundred seedlings of glaucous plants all were glaucous save two.

REVISION OF THE UNITED STATES SPECIES OF FUIRENA. By FRED. V. COVILLE, Department of Agriculture, Washington, D. C.

[ABSTRACT.]

THE forms are grouped under three species and two varieties, as follows:

Fuirena scirpoidea, MX.
simplex, Vahl.
squarrosa, MX.
var. *hispida*, Chapm.
var. *pumila*, Torr.

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A NOTE ON THE REGULARITY OF FLOWERS IN CALAMINTHA NUTTALII, BENTHAM. By DAVID F. DAY, Buffalo, N. Y.

[ABSTRACT.]

THE theory, that sepals, petals, stamens and pistils are the analogues of leaves, naturally suggests that the flower itself is no more than a branch, the axis of which has been suppressed or very greatly shortened. It follows that the normal or typical flower must be regular in plan, and that irregularity is the result of modification. Terminal flowers are, I think, invariably regular, no matter whether erect or pendulous; but when flowers are lateral, we may confidently look for irregularity. I know of no lateral flower, which has not, more or less irregularity. In fact when a flower, though terminal, has an horizontal position, it will usually, and perhaps always, be found somewhat irregular, in one way or another. In the case of lateral flowers, it seems probable, that the cause of their irregularity is the unequal compression to which the bud, in the early stages of its development, is necessarily subjected; some parts of the flower being thereby accelerated in their growth and other parts retarded. The dissection of the bud of any irregular flower, when it has made but little growth, will, I think, always show some evidence of the original regularity of its plan. When, however, a flower, usually lateral in its position, is produced terminally, a greater or less approach towards regularity is manifested. The "Peloria" state of *Linaria vulgaris*, Mill, is an example. The same reversion, as it may be called, to regularity, has been observed, under the same circumstances, in the Gloxinias of the conservatories. But in regard to the *Labiatae*, I do not think that, until the present time, any instance of a reversion to regularity has been recorded. In the summer of 1888, I had occasion to notice that the earliest flowers of *Calamintha Nuttallii*, Benth., a plant quite common in rocky places, along the Canadian shore of Lake Erie, were *terminal* and *regular*.

RESERVE FOOD SUBSTANCES IN TWIGS. By Prof. BYRON D. HALSTED, New Brunswick, N. J.

[ABSTRACT.]

THE investigations were prosecuted during December, 1888, and January, 1889. Reserve food materials of winter twigs are divided into carbohydrates and albuminoids. Iodine in iodide of potash was employed for the detection of starch. Starch was generally found in the pith medullary rays and wood pith of all varieties examined. This testing may be done rapidly by splitting the twigs and plunging the halves in a vessel containing the iodine. Sections for the microscope can afterwards be made as needed. The details of these experiments are given in Bulletin

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No. 4 of the Iowa Experiment Station. Starch is most abundant in mature twigs. In immature branches it is confined to the outermost pith and medullary rays and mostly in the vicinity of buds. There is nothing in the quantity, quality or disposition of the starch of mature twigs that characterizes one variety of apple tree from another. The starch in a tree is not entirely renewed from year to year. Grape sugar was present in variable quantities, as were also cane sugar and dextrine.

Albuminoids were found in all living parts, especially the buds fully matured, and therefore their presence is like that of starch, a test of maturity and not for varieties. Starch is not present in mature buds, because crowded out by the more vital compounds, namely the albuminoids. Crystals of the spherical type were abundant in proximity to all growing points, irrespective of variety.

Grittiness, so-called by grafters and others, is due to a thickening of cell wall by intercalation of lignin. It is best illustrated in the large pith just below a well-matured terminal bud and particularly well seen in the pear twig.

The problem of tenderness, therefore, needs to be approached upon some other line than that of cell-structure and storage of food-materials. If a difference of structure exists, it is most likely among the protoplasmic molecules and therefore beyond the reach of the present microscopes.

Many other plants were tested in connection with the apple twigs. Cherries have only a small amount of starch—a mucilage taking its place. Starch was packed in the pith of pears, even tender sorts. In the currant and gooseberry there is but little starch in the twigs, but large quantities in the root system. The same was true of the Hercules club (*Aralia spinosa*). Willow, poplar and several other trees had no starch in twigs. The roots were not examined. Oaks were rich in starch at the base of cluster of terminal buds. Maples had a moderate amount. Elms, basswood, honey-locust and hackberry and other trees without well-formed terminal buds had but small amounts of starch near the tips, but it was in proximity to buds lower down. The bases of thorns and spines usually contain starch.

This starch gradually disappears as growth begins in spring.

A SUGGESTION CONCERNING SCIENTIFIC WORK. By Prof. WILLIAM R. DUDLEY, Ithaca, N. Y.

FERMENTATION OF ENSILAGE. By Prof. T. J. BURRILL, Champaign, Ill.

[This paper will appear in a bulletin of the agricultural experiment station of the University of Illinois.]

MODERN TEACHING APPLIANCES IN BIOLOGY. By Prof. R. RAMSAY WRIGHT, Toronto, Ont.

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THE RELATION BETWEEN TEMPERATURE AND NUMBER OF VERTEBRÆ IN FISHES. By Prof. DAVID S. JORDAN, Bloomington, Ind.

THE HISTORY AND MIGRATION OF THE AMERICAN CROW IN NEBRASKA. By Prof. W. EDGAR TAYLOR, Nebraska State Normal School, Peru, Nebraska.

NOTES ON THE LOCAL DISTRIBUTION OF SOME BIRDS. By A. W. BUTLER, Brookville, Ind.

ON THE HIGHER DIVISIONS OF THE PELECYPODA. By WM. H. DALL, Washington, D. C.

ON THE CONDITIONS OF MOLLUSCAN LIFE IN THE DEEP SEA. By WM. H. DALL, Washington, D. C.

NOTES ON BIRD'S-EYE MAPLE. By Prof. W. J. BEAL, Agricultural College, Mich.

NOTES UPON STAMENS OF SOLANACEÆ. By Prof. BYRON D. HALSTED, New Brunswick, N. J.

GRASSES OF ROAN MOUNTAIN. By F. LAMSON SCRIBNER, Knoxville, Tenn.

ON THE ASSUMPTION OF FLORAL CHARACTERS BY AXIAL GROWTHS IN ANDROMEDA CATESBÆI. By Prof. THOMAS MEEHAN, Germantown, Philadelphia, Pa.

ON THE SIGNIFICANCE OF DICECISM AS ILLUSTRATED BY PYCNANTHEMUM. By Prof. THOMAS MEEHAN, Germantown, Philadelphia, Pa.

ON THE EPIGYNOUS GLAND IN DIERVILLA AND THE GENESIS OF LONICERA AND DIERVILLA. By Prof. THOMAS MEEHAN, Germantown, Philadelphia, Pa.

ON THE POSITION OF THE NECTAR GLANDS IN ECHINOPS. By Prof. THOS. MEEHAN, Germantown, Philadelphia, Pa.

SOME PHYSIOLOGICAL TRAITS OF THE SOLID STEMMED GRASSES AND ESPECIALLY OF INDIAN CORN (MAIZE). By F. L. STEWART, Murrysville, Westmoreland Co., Pa.

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ON THE GENUS ELEOCHARIS IN AMERICA. By Dr. N. L. BRITTON, Columbia College, New York, N. Y.

ON THE TROPICAL DISTRIBUTION OF CERTAIN SEDGES. By Dr. N. L. BRITTON, Columbia College, New York, N. Y.

ON THE FLORA OF NEW JERSEY. By Dr. N. L. BRITTON, Columbia College, New York, N. Y.

THE NEW BOTANICAL LABORATORY OF BARNARD COLLEGE. By Dr. N. L. BRITTON, Columbia College, New York, N. Y.

ON A CONVENIENT METHOD OF SUBJECTING LIVING CELLS TO COLORING AGENTS. By Prof. GEO. L. GOODALE, Cambridge, Mass.

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ANTHROPOLOGY.

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ADDRESS

BY

PROFESSOR GARRICK MALLERY,

VICE PRESIDENT, SECTION H.

ISRAELITE AND INDIAN.
A PARALLEL IN PLANES OF CULTURE.

Axioms and postulates long limited man's study of man. This hampering has been most marked in reference to America, which it was agreed must have been peopled from the eastern hemisphere, and that the languages, religions and customs found here must have been inherited from nations registered in Eurasian records. Whatever was found here was through descent or derivation, the conceptions of autogeny and of independent growth by which men in the same plane of culture act and think alike not having arisen to explain observed facts.

Many authors have contended that the North American Indians were descendants of the "ten lost tribes of Israel." Prominent among them was James Adair, whose work, highly useful with regard to the customs of the southeastern Indians, among whom he spent many years, was mainly devoted to proof of the proposition. The Rev. Ethan Smith is also conspicuous, and even the last book discussing the Indians, published last year, bearing the comprehensive title "The American Indian," favors the same theory.

The argument that the Indians are descended from the "lost tribes" is weakened by the fact, now generally accepted, that those tribes were not lost but most of the people were deported and absorbed, their traces being left during centuries, and others fled to Jerusalem and Egypt. If any large number of them had remained in a body and had migrated at any time long before the Columbian discovery, but later than the capture of Samaria in the seventh

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century B. C., their journey from Mesopotamia to North America would have required the assistance of miracles that have not been suggested except perhaps in the book of Mormon.

The authors of the school mentioned have for their excuse the fact, which I freely admit with greater emphasis, that an astounding number of customs of the North American Indians are the same as those recorded of the ancient Hebrews; but the lesson to be derived from the parallel between the Indians and the Israelites is very different from that of the descent advocated.

For brevity, the term Indians may be used—leaving the blunder of Columbus where it belongs — without repeating their designation as North American, as I shall not treat of the aboriginal inhabitants south of the United States. This neglect of Mexico, Central and South America is not only to observe my own limits, but because some of the peoples of those regions had reached a stage in advance of the northern tribes. To avoid confusion, the term Israelites may designate all the nation. Although the tribes became divided into the kingdoms of Israel and Judah, when it is necessary to speak of the northern tribes they may be designated as the kingdom of Samaria. The shortest term, Jews, would be incorrect, as the people scattered through the world and called "Jews" are chiefly the descendants of the southern branch or fractional part of the children of Israel and have a special history beyond that common to them with their congeners.

The parallel presented is not selected because the two counterparts are more similar to each other than each of them is to other bodies of people among the races of the earth. I readily admit that a similar parallel can be drawn between both the Indians and the Israelites and the Aryan peoples from which I and most of my hearers are supposed to have descended. The selection is made for convenience, because this audience is supposed to be familiar with the Old Testament, so that quotations and citations are unnecessary; and also because many of them in this, the anthropologic section, are familiar with the Indians, so that the collocation of facts without a prolix statement is sufficient for comparison.

Although the Indians are divided into fifty-eight linguistic stocks and three hundred languages, and there is great variety in their manners, customs and traditions, yet there is sufficient generic resemblance between all of them to allow of typical instances, where the European civilization and missionary influence have not

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effected a change or where the early authorities are reliable. It is essential to examine the other side of the parallel — the Israelites — at a period coincident in development with that of the Indians. The history and records of the Israelites must be chiefly considered regarding the times before they had formed a nationality and had become sedentary. Nearly contemporaneous with that nationality was the general use of writing, and it would appear that the era of King David would be a demarcating line. The Indians, never having arrived at the stage of nationality, though some of them (as the Iroquois and the Muskoki) were far on the road to it, and never having acquired a written language, their stage at the Columbian discovery, allowing for the differences among themselves, shows a degree of development similar to that of the Israelite patriarchal period and the early Canaanite occupation before the rule of kings.

The argument, strongly urged, derived from an alleged similarity between the Hebrew and some Indian languages, especially in identity of some vocables, is not to be considered. Perhaps the most absurd of all the coincidences insisted upon by Adair was the religious use of sounds represented by him to be the same as the word Jehovah. As the deported Israelites did not pronounce the name given in the English version as "Jehovah," and the mode of its spelling and pronunciation is at this moment in dispute—generally given as Jahveh— it would be very remarkable if the tribes of Indians supposed to be descendants of the lost ten tribes of Israel, should at this time know how to pronounce a name which their alleged ancestors did not possess or at least did not use.

Father Lafiteau was so much excited by coincidence in sound of some of the Iroquoian names and expressions with the language of the ancient inhabitants of Thrace and Lycia, that he based thereon a theory of descent. On similar grounds ancestors of the Indians have been found among the Phœnicians, Scandinavians, Welsh, Irish, Carthagenians, Egyptians, Tartars, Hindus, Malays, Chinese, Japanese and all the islands of Polynesia. It is not wonderful that, with the choice of three hundred Indian languages besides their dialects from which to make selections of sounds, some one should be likened to any other language, for any languages that are spoken can, in that manner,— *i. e.*, by a comparison of vocables—show identity of sound and a percentage of coincidences of significance. Philology now makes different rules of comparison.

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It is important to establish the time when writing was first known among the Israelites, because then the traditions would first become fixed. No reliable history can exist before writing. What people remember are fables and myths; from those must be winnowed the history of the time when the people could not write. There is no reason to suppose that the Hebrew language was written at the time of the exodus though some mnemonic system might have been used. If Moses had all the knowledge of the Egyptians he could not have used any better mode of writing than their hieratic, in which it was not possible to write intelligibly any long document in the Hebrew language, simply because the advance made by the hieratic, in which the use of phonetics began, was not sufficient to be adapted to the Hebrew vocables.

There has been an attempt to show that the old Hebrew alphabet, which has been classed as partly Phœnician and partly Babylonian, was obtained from Assyria at a time before the exodus, but the theory is not yet established. Even if Assyrian characters adaptable to the Hebrew language did then exist it is not probable that the Israelite herdsmen did so adapt them with current use.

The compilers of the Old Testament, as we now have it, felt no doubt that the law could have been written on Mount Sinai. They knew how to write and so did their fathers, and it did not occur to them that there had ever been a time in which persons of the higher classes were ignorant of writing.

It is probable that in the days of Samuel the Israelites had made some progress in the art of writing. An alphabet had been known to some of them before, but a common use is of greater consequence and that depends much upon the substances used for writing, their cost and the convenience of procuring them. The people did write under David at, perhaps, about 1100 B. C.

Moses flourished about fifteen centuries before Christ, and the oldest legends relating to him are, in their present shape, four or five centuries later than his death. He did not practically organize any formal state of society, or if he did, temporarily, by his personal power, it had no direct consequence or historical continuity. The old system of clans and religion continued as before. If the legislative portion of the Pentateuch was the work of Moses it remained a dead letter for centuries and not until the reign of Josiah became operative in the national history.

The historical account undoubtedly states that Moses was, by inspiration, the founder of the Torah; but the question is, what was that

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Torah? It was not the finished legislative code. The promulgation of the law at Sinai was long after described dramatically to produce a solemn impression, representing as occurring on a momentous occasion what in fact slowly and imperceptibly grew during ages.

The code now ascribed to Moses was certainly a revised code, and in an unusual sense a mosaic work. When the Israelites attained the use of writing they did as all other people in the world did when they began to use writing; *i. e.*, they wrote out their own myths, traditions and legends as they knew them at the time of writing, unless special reasons made it desirable to manipulate them. There were such special reasons in the later history of Israel, in the contests between the Elohists and the Jahvists. When the compilers belonging to the two schools produced the two versions, intermixed and confused in the books we now have, they differed from all people in history where there was a struggle for political power, if, to suit their own views, they did not color the earlier documents, long since lost, namely: the "Book of the Wars of Jahveh" and the "Jasar."

It is also certain that during the long time in which the traditions were transmitted orally, the growth of the nation's ideas produced a change in them without any fabrication or design.

Students who have devoted their lives to study the last compilation have been able to identify, by linguistic and historical exegesis, the fragments of the original traditions, the epic tales of the first documents, the theocratic deductions and the later sacerdotal visions, though the two versions appear on the same page and sometimes in the same paragraph. The results of this immense labor by the Hebraists of this generation have lately been presented by Renan in a popular form.

In addition to the linguistic and historical tests, the internal evidences, especially the antedating of conceptions several centuries (some instances of which will be mentioned) show that the books, as now received, were written long after the periods referred to in them.

The main document on the primitive age is the Book of Genesis, regarded for the reasons mentioned, not as literally historical, but as the tradition, written at a respectable antiquity, of an age that really existed. In examining it the historical part is discovered, not by belief in the miraculous, but by the proper comprehension of the mythical.

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Much can be learned, from myths and legends, of the periods anterior to strict history. The Homeric epics are not history, yet they throw a flood of light upon Greek life a millennium before the Christian era. The ante-Islam tales and the Arthurian and Niebelungen romances of the Middle Ages are not true in fact, yet they are storehouses, preserving the social life of the days when they were composed and in a useful degree of the time embraced by the traditions. The generalizations derived from the details of ancient texts are truths obtained by induction.

It is expedient to make a disclaimer before entering upon the necessary comparisons of religions. I absolutely repudiate any attack upon any religion. Let us learn a lesson from the Indians, not only in tolerance but in politeness. One of the early Jesuit missionaries in Canada recounts how he pleased a Huron chief by his discourse upon the cosmology set forth in the Scriptures, and felt that he had secured a convert until the chief, thanking him for his information, added: "Now you have told me how your world was made, I will tell you how my world was made"; and proceeded to give the now familiar story of the woman falling from the sky and the turtle. He was perfectly satisfied that the priest should retain his belief with which his own, in his opinion, did not conflict. Doctor Franklin tells of a Susquenannock who, after a similar lecture from a Swedish missionary, was answered in the same manner; but this missionary became angry and interrupted the Indian, whereupon the latter solemnly rebuked him with pity: "I have listened politely to what you told me; if you had been properly brought up you would have believed me as I believed you."

Religion, as accurately defined, embraces only the perficient relations between divinity and man, and the mode in which such relations operate. Popularly it includes cosmology and theology. For present convenience the broad subject may be divided into Religious Opinions and Religious Practices.

In treating it, all religious views personally entertained must be laid aside and the study conducted strictly within the scope of anthropology. A rule of science is not to use a miraculous factor when it is unnecessary. *Nec deus intersit, nisi dignus vindice nodus.* It will be recognized as puerile to explain puzzling phenomena, as was done for ages,

> When solved complete was any portent odd
> By one more story or another god.

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If experience of observed facts and of the orderly working of the forces of nature is not sufficient for any proposed study, some minds resort to the miraculous while others humbly confess ignorance.

In anthropology, the object is to study within the category of humanity. It is undoubtedly true that in their explanation of phenomena, all the peoples of the world have resorted to revelations. Every myth or teaching is directly or indirectly through revelation; but as the revelation is on both sides of the equation, it can be eliminated from any parallel. Religious writers have often explained the differences in beliefs among the various peoples of the world on the hypothesis that religious knowledge was implanted at one time in the ancestors of all those peoples, and that the divergence now found is through decay of that supernatural information.

A distinguished cardinal was rash when, admitting that the doctrine of the devil and his command of demons was not known to the Israelites until after the Babylonian captivity, he insisted that it might be divine revelation, notwithstanding its immediate source. He said that if God made Balaam's ass speak, it would also be easy for him to provide that the heathen should give correct instruction. Doubtless. But this practically means that all revelations suiting us are true and all others false. When the judgment upon the truth or falsehood of an alleged revelation is made only in accordance with the prejudices of the judge, the subject becomes too eclectic and elastic to be considered by science. It is not allowable to impress a new hypothesis to support an older one when the requisition is for facts to convert the first hypothesis into an admitted theory.

Certain it is that the assertion of revelation cannot be dealt with in this address. To raise that point acts as a clôture, cutting off all debate.

RELIGIOUS OPINIONS.

The most generally entertained parallel between the Indians and the Israelites, repeated by hundreds of writers, was that they both believed in one overruling god. This consensus, if true, would at once establish a beatific bridge of union between the two peoples, but its iris arch vanishes as it is viewed closely.

After careful examination, with the assistance of explorers and linguists, I reassert my statement published twelve years ago, that no tribe or body of Indians, before missionary influence, entertained

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any formulated or distinct belief in a single, overruling "Great Spirit," or any being corresponding to the later Israelite or the Christian conception of God. All the statements of the missionaries and early travellers to the opposite effect are erroneous. Even some of the earliest writers discovered this truth. Lafiteau says that the names "Oki" and "Manito" were given to various spirits and genii. Champlain said that Oki was a name given to a man more valiant and skilful than common. "Hawaneu," reduced to correct vocables, only means loud-voiced, *i. e.*, thunder. "Kitchi Manito" is not a proper name for one god, but an appellation of an entire class of great spirits. So with the Dakota term "Wakan," which means only the mysterious unknown. A watch is a wakan. The Chahta word presented as "God" for two centuries is now found to mean a "high hill."

The Indians probably had a vague idea of some good spirit or being whom they did not worship and to whom they did not pray. They prayed and sacrificed to the active daimons, concerning whom they had many myths. It is true that in their various cosmologic myths there was some vague and unformulated being who started the machinery by which the myth proceeded; but when once started no further attention was paid to such originator. Perhaps some modern advanced thinkers have no clearer definition of a great first cause.

Praise has been lavished upon the Indians because they did not take the name of God in vain. That, however, might be because they did not have any word corresponding with the English "God" either to use or misuse, which is the fact according to the best linguistic scholars, and they deserve no more praise for avoidance of profanity than for their total abstinence from alcoholic drinks before such had been invented or imported. The terms "Master of Life," "Maker of Breath" and "Great Father" were epithets merely. Perhaps there was an approach to a title of veneration when the method of their clan system was applied to supernatural persons, among whom there would naturally be a chief or great father of the "beast gods," on the same principle as there was a chieftaincy in tribes.

The missionaries who have persistently found what did not exist are not without excuse. Wholly independent of any design to force welcome answers, an interviewer who asks a leading question of an Indian can always obtain the answer which is supposed to be

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desired. The sole safe mode of reaching the Indian's mental attitude is to let him tell his myths and make his remarks in his own way and in his own language. When such texts are written out, translated and studied they are of great value. It is only within about twelve years that this has been done, to the correction of many popular errors.

It is also true that in attempting to translate the epithets mentioned, the missionaries used the word which, in their own conception, was the nearest in significance. An instructive instance was where Boscana described a structure in southern California as a "temple." It was a circular fence, six feet high, not roofed in—a mere plaza for dancing; but the dancing was religious and the word "temple" was the best one he could find, by which mistake he has perplexed archæologists who sought for the ruins.

A consideration not often weighed is that the only members of the Indian tribes who are willing to give their own ideas on religious matters to foreigners, are precisely those who are most intelligent and most dissatisfied with their old stories. There were minds among them groping after something newer and better, and it would be easy to translate their vague longings into the conception of an overruling Providence. But the people made no such advance.

The missionaries who announced that the Indians were strict in the belief in one god, were much troubled by the statement of the converted native, Hiaccomes, of Martha's Vineyard, who, having enumerated his thirty-seven gods, gave them all up. This, however, was a typical instance of the truth. The Indians had an indefinite number of so-called gods corresponding with the like indefinite number of the Elohim of the Israelites before the supremacy of Jahveh.

The Biblical religion of Israel has been popularly held to be coeval with the world, but it had its own beginning by no means archaic, after which at least four hundred years were required for its development. About a thousand years before Christ it did not exist. The religious practices of David and Solomon did not materially differ from those of their neighbors in Palestine. Not until the time of Hezekiah, about 725 years before Christ, did the Israelite religion attain to a distinct formulation. Its ordinances and beliefs advanced from crudity and vagueness to ripeness and establishment. It was a system long in growth and so could not early possess authoritative documents.

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The nomad Semite believed, with other barbarians, that he lived amid a supernatural environment. The world was surrounded and governed by the Elohim—myriads of active beings, seldom with distinct proper names, so that it was easy to regard them as a whole and confound them together. Yet the power bore different names in different tribes. In some cases it was called El, or Alon, or Eloah; in other cases Elion, Saddai, Baal, Adonai, Ram, Milik or Moloch.

The Elohim, though generally bound together, sometimes acted separately; thus each tribe gained in time its protecting god, whose function was to watch over it and direct it to success.

In the transition to nationality, the Israelites adopted a national god, Jahveh, who was not just, being partial towards Israel and cruel towards all other peoples. The worship of a national god is not monotheistic but henotheistic, recognizing other gods of other peoples. The work of the later prophets consisted in restoring the attributes of the ancient elohism under the form of Jahveh, and in generalizing the religious cult of a special god.

Jahveh was not at first the god of the universe, but subsequently became so because he was the God of Israel, and very long afterwards was claimed to be the only god, mainly because the Israelites claimed to be the peculiar people. Even down to the time of the prophet Isaiah, there were intermittent conflict and co-ordination between Baal together with the other gods of Canaan and Jahveh.

The revolution accomplished by the prophets did not change expressions. The word Jahveh was too deeply rooted to be removed, and the people spoke of Jahveh as they had formerly spoken of the Elohim. He thus became the supreme being who made and governed the world. In time even the name of Jahveh was suppressed and its utterance forbidden; and it was replaced by a purely theistic word meaning the Lord. Undoubtedly the prophets, at the time of the Kings and later, taught the worship of one God, but the people were not converted to the doctrine until after the great Captivity.

When established in Palestine, the Israelites entered into communion with their Canaanite kindred and worshipped Baal. With less apparent reason they frequently bowed down to the Dagon of the Philistines and the Ashtaroth of the Phœnicians. Solomon introduced the service of the Sidonian Astarte, which was intermitted, but later, Ahab established the worship of the Sidonian divinities in the Kingdom of Samaria. It was subsequently re-adopted in the

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kingdom of Judah, and not until the reign of Josiah were their altars finally demolished.

The true parallel, therefore, between the Indians and the Israelites, as to belief in a single overruling god is not that both, but that neither, held it.

In the stage of barbarism all the phenomena of nature are attributed to the animals by which man is surrounded, or rather to the ancestral types of these animals, which are worshipped. This is the stage of zoötheism. Throughout the world, when advance was made from this plane, it was to a stage in which the powers and phenomena of nature are personified and deified. In this stage the gods are anthropomorphic, having the mental, moral and social attributes of men, and afterwards having the forms of men. This is the stage of physitheism. The most advanced of the Indian tribes showed evidence of transition from zoötheism to physitheism. The Israelites, in the latter part of the period selected, showed the same transition in a somewhat higher degree than the Indians did when their independent progress was arrested.

It is needless to enlarge upon the animal gods of the Indians, or to furnish evidence that they gave some vague worship to the sun, the lightning, to fire and winds.

There is no doubt that the Israelites were for a long period in the stage of zoölotry. They persisted in the worship of animal gods: the golden calf, the brazen serpent, the fish-god and the fly-god. The Second Commandment is explicitly directed against the worship of the daimons of air, earth and water, which is known to have been common; and the existence of the prohibition shows the necessity for it, especially when formulated, after the practice had existed for centuries, by a religious party which sought to reform it.

The God of Sinai was a god of storm and lightning, which phenomena were strange to the Israelites after their sojourn in plains. The ancient local god of the Canaanites began in the exodus to affect the religious concepts of the Israelites so that they identified Jahveh with the god whose lands they were planting and whose influence they felt. Sinai was thenceforward the locality of their theology. Jahveh, through all changes, remained there as his home; he spoke with the voice of thunder and never appeared without storm and earthquake.

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Another class of gods connected with beast worship and also with the totemic institution (to be hereafter specially noted) was tutelar, the special cult of tribes, clans and individuals. It was conspicuous both among the Israelites and the Indians.

Jahveh, according to all that is known, may first have been a clan or tribal god, either of the clan to which Moses belonged or of the clan of Joseph, in the possession of which was the ark. No essential distinction was felt to exist between Jahveh and El, any more than between Ashur and El. Jahveh was only a special name of El which had become current within a powerful circle, and which, therefore, was better fitted to become the designation of a national god. When other tutelar gods did not succeed, there was resort to Jahveh, probably in the early instances, because he was the most celebrated of all the tutelar gods, and the reason for that celebrity was that the most powerful of the clans claimed him as tutelar.

Hecastotheism is a title given to the earliest form of religion known, which belongs specially to the plane of savagery. In it every object, animate or inanimate, which is remarkable in itself or becomes so by association, is a *quasi* god. The transition between savagery and barbarism, as well as between the religions of hecastotheism and zoötheism connected with them, was not sharply marked, so that all their features could exist at the same time at a later era, though in differing degrees of importance.

This intermixture is found both among the Israelites and Indians. An illustration among many is in the worship of localities and of local gods. Conspicuous rocks, specially large trees, peculiar mountains, cascades, whirlpools and similar objects received worship from the Indians; also the places where remarkable occurrences, as violent storms, had been noted; and among some tribes the particular ground on which the fasting of individuals had taken place, with its accompanying dreams. The Indians frequently marked these places, often by a pile of stones; but the Dakotas, when they did not have the stones, used buffalo skulls.

In the Old Testament frequent allusions are made to a place where dreams or remarkable events occurred becoming holy. They were designated by pillars. The Israelite compilers adopted the pillar of Bethel for the same reason that required Mohammed to adopt the Caaba. They could not, while struggling for monotheism, always directly antagonize the old hecastotheism.

Future state.—The topic of a future state may be divided into

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(1) the simple existence of the soul after death, (2) the resurrection of the body, and (3) the rewards and punishments in the next world.

The classical writers often distinguished two souls in the same person—one that wandered on the borders of the Styx until the proper honors had been given to the corpse; and the other was a shadow, image or simulacrum of the first, which remained in its tomb or prowled around it. The latter could be easily invoked by enchanters.

Some of the Indians thought that the souls of the dead passed to the country of their ancestors, from which they did not dare to return because there was too much suffering on the road forward and backward. Nevertheless, they believed that there was something spiritual which still existed with their human remains and they tell stories of it. Thus there are two souls, and the Dakotas have four, one of which wanders about the earth and requires food, the second watches over the body, the third hovers around the village, and a fourth goes to the land of spirits.

The Iroquois and Hurons believed in a country for the souls of the dead, which they called the "country of ancestors". This is to the west, from which direction their traditions told that they had migrated. The soul must go there after death by a very long and painful journey, past many rivers, and at the end of a narrow bridge fight with a dog like Cerberus, and some of them fall into the water and are carried away over precipices. In a manner difficult to understand, this road is all on the earth; but several of the Indian tribes consider the milky-way to be the path of souls, those of human beings forming the main body of the stars, and the dogs, which also have souls, running on the sides. In their next world the Indians do precisely the same as they customarily do here.

The Israelites believed in a doubling of the person by a shadow, a pale figure, which after death descended under the earth and there led a sad and gloomy existence. The abode of these poor beings was called Sheol. There was no recompense, no punishment. The greatest comfort was to be among ancestors and resting with them. There were some very virtuous men whom God carried up that they might be with him. Apart from these elect, dead men went to oblivion. Man's good fortune was to have been accorded a number of years, children to perpetuate his family and his memory to be kept in respect after his death.

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The Indians did not believe in death as a positive state. The spirit does not wholly leave the body and the body is not resurrected. Perhaps a good instance of their belief is that of a tribe of Oregon Indians who, hearing the missionaries preach on the resurrection, immediately repaired to an old battle-field and built great heaps of stones on the graves of their fallen foes to prevent their coming up again. They did not want any of that.

Among the Israelites the resurrection of the body was a foreign idea imbibed during the captivities in Assyria and Babylonia. Perhaps the first reference made to it is in the prophet Daniel. It was not fully believed in so late as the procuratorship of Pontius Pilate.

Among the Indians privation of burial and funeral ceremonies was a disgraceful stigma and cruel punishment. There was trouble about children who died shortly after their birth, and also about those whose corpses were lost, as in the snow or in the waters. In ordinary cases of death the neglect of full and elaborate ceremonies caused misfortune to the tribe.

The story of the "happy hunting ground" among the Indians has not been generally apprehended. As regards what we now consider to be moral conduct there was no criterion. A good Indian was one who was useful to his clan and family, and was, at the time of his death, not in a condition of violating the clan rules, for which the Polynesian word tabu has been adopted. The moral idea of goodness of a Pawnee chief is to be a successful warrior or hunter. The actual condition at the time of death decided the condition in the future life far more than any conduct during life. In the portions of the continent where the scalp was taken, the scalped man remains scalped in the world of spirits, though some tribes believed that scalping prevented his reaching that world. If he had but one leg or eye here, he had but one leg or eye afterwards. In tribes where they cut off the ears of slain foes the spirit remains without ears. A special instance is where the victim was considered too brave to be scalped, but the conquerors cut off one hand and one foot from the corpse to keep him from inflicting injury upon the tribe of the conquerors in the next world. If an Indian died in the night some of the tribes thought that he remained in total darkness ever afterwards.

One of the most curious of their beliefs was in connection with drowning and hanging, the theory being that the spirit (which was

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in the breath) did not escape from the body. This doctrine was made of special application to prevent suicide which was generally performed either by hanging or drowning, the deduction being that suicides could not go to the home of the ancestors.

It is probable that the various trials by which the spirit is supposed to reach the other world, which were very numerous in the different tribes, were invented to secure confidence in the absence thereafter of the ghosts of the dead, because the same difficulty would attend their return. As without the assistance of the mortuary rites, given at the time of death and sometimes for considerable periods afterwards, the ghosts would not be able to reach their final home, there being no repetitions of those rites to assist their return, their absence was secured. Fear of the ghosts, not only of enemies but of the dearest friend, generally prevailed. After a death all kinds of devices were employed to scare away the spirit. Sometimes a new exit was cut through the wigwam, through which the corpse was taken, and afterwards filled up, it being supposed that the spirit could reënter only by the passage through which it went out. Sometimes the whole wigwam was burned down. There was always a long period which travellers called that of mourning during which drums and rattles were used to drive away the spirits. After firearms were obtained they were discharged in and around the late home of the deceased with the same object. The loud cries of so-called lamentation had probably a similar origin, and this is more marked when the lamenters were strangers to the dead, and even professionals, not unlike the Irish keeners.

In this general connection it is proper to allude to the common abstinence from mentioning the true name of any dead person. This is more distinct than the sociologic custom where the man's true name should not be used in his life except on special occasions. There was some fear that, by calling his name, he might come back.

It would be wrong to accuse the Indians of want of feeling indicated by their horror of the dead. In one of the most ancient accounts — that of Cabeza de Vaca — it is declared that the parents and other relatives of the sick show much feeling while life remains but give none to the dead—do not speak of them or weep among themselves or make any signs of grief or approach the body. This domestic reticence is entirely different from but not antagonistic to the obligatory mortuary rites which were practised.

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To secure the living from the presence of the spirits of the dead was the first object, and the second was to assist those spirits in the journey to their destination. These were the prevailing ideas of all the mortuary customs of the Indians. It may be true that there was in some cases, though missionary influence is to be suspected, a belief that there were two different countries (sometimes called towns) in which the bad and the good would severally remain, but that was not of general acceptance. There was but one future country, and the only question was whether the spirits got there or not. There was no hell.

The Israelites, in their sacred books, do not show the influence of fears or hopes concerning a future state with reference to individual morality. Among them death was not an inevitable necessity, but an infliction as a punishment and their signs of mourning were acts of penitence and contrition, with the idea that the survivors might have been the cause of the death. All deaths were classed with public calamities, such as pestilence, famine, drought or invasion, being the work of an enemy—perhaps a punishing god, perhaps a daimon or a witch. They regarded it so great an evil to die unlamented that it was one of the four great judgments against which they prayed, and it was called the burial of an ass. It is however questionable whether rites attending upon death were not with them similar in intent to those of the Indians; *i. e.*, to provide, by means of those rites, for the future welfare of the departed, rather than in accordance with our modern sentiment, to show respect. Passages of the Old Testament may be noted, *e. g.*, the one telling how the bodies of Saul and his children were rescued from Bethshan and taken to Jabesh where they were burned and the bones buried. The ceremony in this case and others seems to have been the burning of the flesh and the burial of the bones, as was frequently done by the Indians on occasions of haste, without waiting as usual for the decay of the flesh, the later gathering of the bones being at stated periods of years.

There is no evidence that the Israelites feared the corpse and its surroundings beyond that to be inferred from the ordinances concerning pollution.

RELIGIOUS PRACTICES.

There should always be a cross reference in thought between what in time became a religious practice and the earlier sociology,

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which will be mentioned in its place, with which it was closely connected.

Josephus remarks about the Israelites that "beginning immediately from the earliest infancy nothing was left of the very smallest consequence to be done at the pleasure and disposal of the person himself."

The same remark would be true regarding the Indians. Their religious life was as intense and all-pervading as that of the Israelites. It is yet noticed in full effect among tribes as widely separated, both by space and language, as the Zuñi and the Ojibwa, and their practices are astonishingly similar in essence and even in many details to some of those still prevailing among us.

Among the Hurons and Iroquois, there were religious rites for all occasions, among others for the birth of a child, for the first cutting of the hair of a child, for its naming and for its puberty, for the admission of a young man into the order of warriors and the promotion from warrior to chieftaincy; for the making of a mystery-man, for the putting of a new canoe into the water, for the breaking of ground for new fields, for the sowing and harvest, to fix the time for fishing, to decide upon a warlike expedition, for marriages, for the torturing of captives, for the cure of disease, for consulting magicians, invoking the daimons and lamenting the dead.

Shamans.—Among the Indians there was frequently an established and recognized priesthood, obtained by initiation into secret religious societies, corresponding in general authority with the Levites, although the latter were instituted in a different manner, perhaps imitated from the exclusive class of the priesthood in Egypt. The shamans in all tribes derived a large part of their support from fixed contributions or fees.

Adair describes a special ceremony for the admission or consecration of a priest among the southern tribes, as follows: "At the time of making the holy fire for the yearly atonement of sin, the Sagan clothes himself with a white ephod, which is a waistcoat without sleeves, and sits down on a white buckskin, on a white seat, and puts on it some white beads, and wears a new pair of white buckskin moccasins, made by himself, and never wears these moccasins at any other time."

Similar exclusive use by the High Priest of the garments used on the day of the atonement is mentioned in Leviticus.

In addition to the organized class mentioned, there were other

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professional dealers in the supernatural who may be called conjurers, sorcerers or prophets, but were independent of and often antagonistic to the regular shamans. They arrived at recognition individually by personal skill in an exhibition of supernatural power, that is, they wrought miracles to prove themselves genuine.

At the time of the exodus there were, among all the Semitic tribes, sorcerers who possessed mysterious secrets and enjoyed some of the power of the elohim. They were paid to curse those whose ruin was desired. Balaam was the most distinguished sorcerer of that time.

One of the most frequent purposes for employing supernatural agency was to bring on rain in time of drought. The practitioner generally tried to delay his incantations as long as possible in hopes of a meteorologic change. Sometimes, on failure, he was killed, as he was supposed to be an enemy who possessed the power he professed but was unwilling to use it; and to prevent this dangerous ordeal in a dry season, he charged in advance certain crimes and "pollutions" of the people on account of which all his skill would be in vain. The more skilful rain-makers among the Sioux and the Mandans managed not to be among the beginners, but towards the last of the various contestants. The rain would surely come some time, and when it came the incantations ceased. The shaman who held the floor at the right time produced the rain.

Frequent reference to rain-making is found in the Old Testament, in which the prophets were the actors.

The mystery-men were consulted on all occasions as sources of truth, not only to explain dreams, but secrets of all kinds, to predict future successes in war or to tell the causes of sickness; to bring luck in the hunt or in fishing; to obtain stolen articles, and conversely, to produce ill luck and disease. Their processes, together with thaumaturgic exhibitions, included some empiric knowledge, and also tricks of sleight-of-hand and magnetic passes.

The Chahta had a peculiar mode of finding the cure for disease, by singing successively a number of songs, each one of which had reference to a peculiar herb or mode of treatment. The preference of the patient for any song indicated the remedy.

The Israelites believed that diseases as well as accidents without apparent cause, and other disasters, were the immediate acts of the Elohim or were caused by evil spirits; therefore they relied upon prophets, magicians or enchanters for exorcism. Hezekiah's

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boil was cured by Isaiah. Benhadad, king of Syria, and Naaman, the Syrian, applied to the prophet Elisha. All the people resorted to their favorite mystery-men.

Even so late as the time of Josephus it was believed that Solomon had invented incantations by which diseases were cured, and some handed down by tradition were commonly used. Incense banished the Devil, which also could be done by the liver of a fish. Certain herbs and roots had the same power. Their medical practices might be recited, with slight change of language, as those of the Indians. The farther back any examination is made into savagery and barbarism the more prevalent faith-cure appears.

Witches.— The Indians were in constant dread of witches, wizards and evil spirits; but the activity of the good spirits was not so manifest. They however told Adair how they were warned by what he calls angels, of an ambuscade, by which warning they escaped. Bad spirits, or devils, were the tutelar gods of enemies, to be resisted by a friendly tutelar. The idea of a personal Satan was not found before the arrival of the missionaries.

Among the Indians witches were often indicated by the dreams of victims, and were often killed merely upon accusation, and it is interesting to notice, with relation to comparatively modern history, that the accused frequently confessed that they were sorcerers and declared that they could and did transform themselves into animals, become invisible and disseminate disease.

A sufficient reference to the Israelites in this connection is to quote the ordinance: "Thou shalt not suffer a witch to live." This injunction, in the higher civilization, is observed by destroying the idea that witches ever have lived or ever can live.

Dreams and divination.—The topics of inspiration by dreams and divination by oracles may be grouped together.

The Indians supposed that with, and sometimes without, a special fasting, and other devices to produce ecstasy, the spirits or daimons manifested themselves in dreams, and it was sometimes possible in these dreams for the soul to leave the body, even to visit the abode of departed spirits.

Among the Iroquoian tribes the suggestions made by dreams were implicitly followed, not only by the dreamer, but by those to whom he communicated his dreams. For instance, an Iroquois dreamed that his life depended upon his obtaining the wife of a friend, and though the friend and his wife were living happily, and parted

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with great regret, the dreamer had his wish. The same tribe had a special feast which was called the "feast of dreams," and partook of the nature of Saturnalia. Every object demanded by the dreamers must be given to them, and in some instances they were unable to remember their dreams, and the special interposition of the mystery-men was invoked to state what their dreams were in fact and what was their significance.

Among the invaluable reports of the Jesuit missionaries, one in 1639 gives the general statement that the Indians consulted dreams for all their decisions, generally fasting in advance; that, in fact, the dream is the master of their lives; it is the god of the country and dictates their decisions, hunts, fishing, remedies, dances, games and songs.

The belief in revelations through dreams was universal, and the gift of explaining them was also a revelation. Their legends on this subject recall those about Joseph and Daniel. In addition may be quoted:

"In a dream, in the vision of the night, when deep sleep falleth upon men, in slumberings upon the bed.

"Then He openeth the ears of men and sealeth their instruction."

And in Deuteronomy a prophet is equivalent to a dreamer of dreams.

There were a variety of oracles among the Indians. Those most interesting to me are connected with pictography. Among many tribes, especially the Mandan, Hidatsa, Minnitari and Abnaki, after certain fasts and exercises various hieroglyphics deciding the questions which had been propounded appeared on rocks. They were deciphered by the shaman who had made them.

The apparatus by which Jahveh was consulted was the urim and thummin, a form of oracle described as connected with the ark. It ceased to be known in the fifth century before Christ and is now but vaguely understood. From the description and tradition it could, physically, have been worked by a custodian.

Severe fasts were probably the most common of the Indian religious practices, continued until they saw visions, sometimes for their own personal benefit, as deciding upon their names to be adopted from the advent of a guardian spirit, and sometimes for tribal advantage, the doctrine of all of them, as Father Lafiteau quaintly observes, being the same that prevailed among many people of his day, to lead the mind from gross and carnal obstructions

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of the body. The real effect was to produce mental disorder. This ecstasy obtained by fasting was often accelerated by profuse sweating and the use of purgative or emetic drinks. Violent and prolonged exercise by dancing in a circle until the actors dropped in a swoon sometimes concluded the ceremonies.

The Israelite prophets were excited to inspiration by external means, such as dances and orgiastic proceedings resembling those of the dervishes and also of the Indian mystery-men. Music was a general accompaniment of the ecstasy. When they were about to prophesy, they became in a condition of frenzy, as if they were beside themselves. When Elisha sent one of the children of the prophets to anoint Jehu it was said of him: "Wherefore cometh this mad fellow?"

The Israelites, when they adored the golden calf sat down to eat and drink and then arose to dance and sing and the Indians used dance and song, or rather chant, in the same religious manner. The Hebrew festival (Hag) is closely connected with dancing in a circle.

Pollution and purification.—The subject of pollution and purification has been much and properly insisted upon as affording a striking parallel between the Israelites and the Indians. The Indians made special huts for the women, at certain periods, who were considered so unclean that nothing which they touched could be used. A Muskoki woman, after delivery of a child, was separated from her husband for three moons (eighty-four days). This may be compared with the Levitical law by which the mother of a female child was to be separated eighty days; of a male forty days; and Doctor Boudinot says that in some Indian tribes there was similar distinction between male and female children.

Among the southern Indians wounded persons having running sores were confined at a distance, as in the Levitical law, and kept strictly separate. An Israelite, dying in any house or tent made all who were in it, and all the furniture in it, polluted, and this pollution continued for seven days. All who touched a corpse or a grave were impure for the same time. Similarly, many of the Indians burned down the house where there had been a death, and all persons in it were polluted.

Many writers have asserted, as one of the excellencies of the Israelite customs, that the purification imposed upon those who had been engaged in a burial was a sanitary regulation, a measure ren-

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dered expedient in a hot country. As no great proportion of the Israelites generally inhabited a country hot to the degree indicated, or had any conception of disease or the cause of death, this explanation is hardly sufficient. Much later the compilers might have gained some sanitary knowledge by which the old superstition was utilized. Its true explanation is from supernatural, not from natural concepts. It is probably connected with a point mentioned before; *i. e.*, the avoidance of corpses from the fear of the spirit of the dead and of the bad spirit which had caused the death, and the purificatory ceremony was for the demon, not for the disease. The neglect of sanitation is well illustrated among the Navajo, who are little affected by civilization. Upon the death of one of their members they block up the shelter containing the corpse and from fear of the spook or of the agent of death, or of both, not from fear of the corpse itself, never again visit it. Other tribes pile stones on the corpse which prevent its disturbance by beasts, but do not absorb the effluvium. Still others exposed the dead on scaffolds. To leave corpses to putrefy freely is certainly not a sanitary measure, yet it was a practice existing together with the mortuary rites before mentioned, though many of the tribes used earth burial and a few used cremation.

On a broad examination of the topic of "pollution," so styled by most writers, it seems to be best explained by our recent understanding of tabu.

Sacrifice.—Man once imagined superior forces who yet could be invoked and moved to and from any purpose. The divine world was produced in his own image and he treated its gods as he liked to be treated by his inferiors. He believed that the way to placate the forces surrounding him was to win them over as men are won over, by making presents to them. This clearly continued among the Israelites until the eighth century B. C., but it is to be regarded as a stage succeeding a former condition of zoölotry and totemism without notice of which its details cannot be understood.

Most peoples sacrificed to their divinities animals taken from their flocks, plants, fruits and herbs. People who had no domestic animals offered those taken in the hunt. The Indians offered the maize from their fields and the animals of the chase, and threw into the fire or water tobacco, or other herbs which they used in the place of tobacco. Sometimes these objects were hung up in the air above their huts. The northern Algonquins tied living dogs to

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high rods and let them expire. In a similar manner other Indians stuck up a deer, especially a white deer, on poles. The plains tribes gave the same elevation to the head or skin of an albino buffalo on mounds, not having poles convenient. The spotless red heifer of the Israelites may be compared with the spotless white of the animals of the chase.

The southern Indians always threw a small piece of the fattest of the meat into the fire when eating or before they began to eat. They commonly pulled their newly-killed venison several times through the smoke of the fire, perhaps as a sacrifice and perhaps to consume the life spirit of the animal. They also burned a large piece and sometimes the whole carcass of the first buck they killed either in the winter or the summer hunt. The Muskoki burn a piece of every deer they kill.

The Israelites offered daily sacrifice in which a lamb (except the skin and entrails) was burned to ashes. In some of their sacrifices there was not only distinction between animals that were fit and unfit, but in the manner of treatment. Sometimes the victim was not to be touched, but should be entirely consumed by fire. In others the blood should be sprinkled around the altar and the fat and the entrails burned, the remainder of the body to be eaten by the priests. But it was a crime to eat flesh that had been offered in sacrifice to a false god.

The offering of the first fruits and therefore of the first born, to the divinity, was one of the oldest ideas of the Semites. Moloch and Jahveh were conceived as being the fire, devouring that which was offered to it, so to give food to the fire was to give to the god. In time, a substitute was suggested; the first born was replaced by an animal or a sum of money. This was called the "money of the lives."

Adair says that at the festival of the first fruits the southern Indians drank plentifully of the "cusseena" and other bitter liquids, to cleanse their bodies, after which they bathed in deep water, then went sanctified to the feast. Their annual expiation of sin was sometimes at the beginning of the first new moon in which their corn became full-eared, and sometimes at the accidental season of harvest. They cleansed their "temple" and every house in the village of every supposed polluting thing, carrying out the ashes from the hearths. They never ate nor handled any part of a new harvest till some part of it had been offered up; then they had a

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long fast "till the rising of the second sun," taking their emetic drink. On the third day of the fast the holy fire was brought out and it was produced, not from any old fire, but by the rubbing of sticks. From this it was distributed to the people.

Lafiteau says that the first animal the young hunter kills he burns with fire as a sacrifice. Another festival was a kind of holocaust, where nothing of the victim was left, but must all be consumed, even to the bones, which were burned. There were also feasts of first fruits.

The Dakotas allowed no particle of the food at one of their religious feasts to be left uneaten. All bones were collected and thrown in the water that no dog might get them or women trample over them. It was common among many of the tribes that no bones of the beast eaten should be broken. There is no doubt that this is connected with zoölotry and was intended to prevent anger on the part of the ancestral or typical animal, the result of which would be the disappearance of the game. There were many other ceremonies of the same kind. When the Mandans had finished eating at any time they presented a bowlful of the food to a buffalo head, saying, "Eat this," evidently believing that by using the head well the living buffalo would still come and supply them with meat.

It is probable that what the authors have called the "day of atonement" or "expiation" was really a general wiping-out of offences or settlements of accounts between individuals and particularly between clans, after which there should be no reprisal. This is illustrated by a peculiar ceremony among the Iroquois, strongly resembling the scapegoat of the Israelites. A white dog, before being burned at the annual feast, was loaded with the confessions or repentings of the people, represented by strings of wampum. The statute of limitations then began to operate.

In the Jahvistic version, the Passover, an old festival held in the spring, was historically connected with the departure from Egypt. The ceremonies are too well known to require narration, but will readily be compared with those of the Indians.

Incense.—The use of the incense among Indians was the same as among Israelites, *i. e.*, to bring, and to please the spirit addressed. A genuine instance among the Iroquois was where tobacco was offered so late as 1882 and in archaic formal language still preserved, translated as follows:

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Address to the fire. "Bless thy grandchildren, protect and strengthen them. By this tobacco we give thee a sweet-smelling sacrifice and ask thy care to keep us from sickness and famine."

Address to the thunder. "O grandfather! thou large voiced, enrich and bless thy grandchildren; cause it to rain so that the earth may produce food for us. We give this tobacco as thou hast kept us from all manner of monsters."

The Dakotas not only burned tobacco in their buffalo medicine to bring the herds, but used scented grass. Other tribes burned the leaves of the white cedar. These forms of incense were also used to entice the inimical spirits, the shaman being supposed to be able, when they had arrived in the form of a bear or some other animal, to kill them with his rattle. Some of the Indians believed that incense and sacrifices generally were only used for the spirits from whom they feared harm. They said it was not necessary to trouble themselves about the good spirits who were all right anyhow.

Fetiches.—Among many of the tribes of Indians there is a tribal totem (and often several clan totems) which, in later times becoming chiefly symbolic and emblematic, was once used in objective form for the most important religious purposes. Particularly, it was carried on extensive warlike expeditions. Adair, who calls it an "ark," describes it as made with pieces of wood, fastened together in the form of a square, to be carried on the back. It was never placed on the ground nor did the bearers sit on the earth when they carried it. In many other tribes it was a bag of skins and its contents varied, but generally were "blessed" or "sacred" fragments of wood, stone or bone. Among the Omaha it was a large shell, covered with various envelopes and was never wholly exposed to sight, which would occasion death or blindness.

A custodian was appointed every four years by the old men of the Blackfeet, to take charge of the sacred pipe, pipestem, mat and other implements which he alone could handle.

The ark of the Israelites was probably derived from the Egyptians who had a real ark, which was carried on the shoulders of the priests in processions. When the exodus began the Egyptian ark, for convenience, was changed into a chest fitted with staves for bearers. It became the standard of their warring and wandering life.

In addition to what has been called the ark or tribal fetich, the

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practice that each Indian had his own mystery-bag is to be compared with the Israelite teraph which was a family or tutelary fetich independent of the national worship and frequently was the subject of later denunciation. It was probably made of carved wood, often carried on the person, but was generally held as a household god or domestic oracle. The teraphim markedly resembled the Roman penates.

This comparison is explanatory of the statement that neither the Israelites nor the Indians made idols. Its truth depends upon what is considered to be an idol. If the definition is limited to the human form, the assertion is true, because their religion was not anthropomorphic; but fetiches were certainly the objects of worship, the recrudescent forms of which, appearing even in civilization, have been amulets, lucky stones, pieces of wood and charms.

Sabbath.—It is not possible, in discussing the Israelites, to neglect the institution of the Sabbath. The four quarters of the moon made an obvious division of the month, and wherever the new moon and full moon are made religious occasions there comes a cycle of fourteen or fifteen days, of which the week of seven or eight days forms half. It is significant that in the older parts of the Hebrew Scriptures the new moon and the Sabbath are almost invariably mentioned together. Among the Israelites and perhaps among the Canaanites, from whose speech they borrowed, joy on the new moon became the type of religious festivity in general. There is an indication that in old times the feast of the new moon lasted two days, so that an approximation to regular recurrence of the subdivisions constituting the week was gained. The Babylonians and Assyrians had an institution dividing the month into four parts, by which, on the days assigned, labor was forbidden; but originally the Israelites' abstinence from labor was only incidental to their not working at the same time that they were feasting. While nomads, with only intermittent work, they had no occasion for a fixed day of rest.

The new moons were at least as important as the Sabbath until the seventh century before Christ. When the local sacrifices were abolished and the rites and feasts were limited to the central altar which practically could only be visited at rare intervals, the general festival of the new moon ceased. The Sabbath did not, but with the abolition of local sacrifices it became an institution of law

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divorced from ritual. The connection between the week of seven days and the work of creation is now recognized as secondary. The original sketch of the decalogue probably did not contain any allusion to the creation, and it is even doubtful whether the original form of Genesis distributed creation over six days.

Subsequent history of the Sabbath shows a reflex action between religion and sociology. Religion prevailed against better arrangements for periods of rest. Sociology used religion to get what it could.

The Indians reached the first part only of the inception of the Sabbath in the ceremonies of the new moon, which were to them of great importance.

Circumcision.—This, generally regarded as a distinctive mark of the Israelites, is by no means peculiar to them, did not originate with them, and is found in so many parts of the world with such evidences of great antiquity as to contravene its attribution to them. Its origin is a subject of great dispute. As practised indiscriminately in infancy, it may perhaps, be a surgical blunder. It is certain that it was not at first among the Israelites a religious rite. The operation was not performed by the priesthood, but by a secular person of skill, without ceremony. It afterwards was regarded as an initiatory ceremony, and as such its parallels may be found all over the world, but as a special national distinction the declared object was not accomplished. Besides the Egyptians, Arabs and Persians, the coincidence with whom might be expected, many tribes of Africa, Central and South America, Madagascar and scores of islands of the sea show the same mark, and it has even been found in several of the North American tribes. The sole motive for alluding to this very comprehensive subject is to correct the popular belief that the custom is peculiar to the Israelites.

Parallel myths.—The Indian myths and legends supporting and explaining the religious opinions and practices before mentioned have a startling resemblance to those of the Israelites. It is not necessary to mention the deluge legends, which are common all over the world, at least in countries where inundations have occurred, and no more than general interest attaches to the mythical teacher, an inspired man or benevolent god in shape of man, who taught all that is known about hunting, fishing, the properties of plants, picture-writing and indeed every art, and founded institu-

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tions and established religions, after which he generally disappeared, his actual death being seldom established. The legends of Michabo, Ioskeha, Hiawatha, Wasi and Manabosho will occur to all students as showing their analogue in Moses. A point of peculiar moment, however, is that the myths referred to are so strikingly identical in their minute details with those of the Israelites, even after all care has been taken to eliminate European influence and to assure their aboriginal antiquity.

An Ojibwa tradition tells the adventures of eight, ten and sometimes twelve brothers, the youngest of whom is the wisest and the most beloved of their father and especially favored by the high powers. He delivers his brothers from many difficulties, brought about by their folly and disobedience. Particularly, he supplies them with corn. A variant statue of Lot's wife, in stone instead of in salt, is still shown near the Mississippi River. The Chahta have an elaborate story of their migrations in which they were guided by a pole leaning in the direction to which they should go and remaining vertical where they should camp. A still closer resemblance to the guidance of the Israelites in the desert is in the migrations of the Tusayan where indication was made by the movement and the halting of a star. The Pai Utes were supported in a great march through the desert by water continually filling the magic cup until all were satisfied; and a similarly miraculous supply of food to starving exodists is reported.

Among the Ojibwa traditions there is a variant of the conception that man could not look upon the form of a divine being and live. In this case the divine beings were obliged to wear veils, and when one of them unintentionally let his eyes fall upon the form of a man the latter instantly fell dead as if struck by lightning.

The Medawe rite was granted the Ojibwa at the time of a great trouble through the intercession of Manabosho, their universal uncle, and rules of life were given them at the same time, which are represented in hieroglyphs on birch bark. They have a resemblance in motive to the Biblical legends and laws. At the time of a great pestilence, which was when the earth was new, the Ojibwa were saved by one of their number to whom a spirit, in the shape of a serpent, revealed a root which to this day they name the "snake-root," and the songs and rites of that medicine are incorporated in the Medawe.

Mr. Warren mentions that sometimes he translated to the old

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Ojibwa men parts of Bible history, and their expression invariably was: "The book must be true, for our ancestors have told us similar stories generation after generation since the earth was new."

Last year a well informed representative of the Muskoki, in Washington, answered questions about the myths and legends of his people by the simple remark: "They are all in the Old Testament. Read them there without the trouble of taking them down from our people."

SOCIOLOGY.

The golden age of the Israelites, as recorded in compliance with tradition, was that ending with the Judges, when the people, without a monarchy, lived in a state nearest the ideal under a supposed theocracy, which also was a later idea. The exploits of Gideon, Jephtha and Samson are grand pictures of antiquity equal and similar to those in the Homeric poems. If the Indians could have written about their own past they would have portrayed a similar golden age, which, in fact, is mirrored in their traditions and myths. But from the absence of flocks and herds they were never in a true pastoral or nomadic state, and therefore never in the absolute patriarchal stage.

The Dakota, Comanche and some other tribes became adventitiously nomads only after the introduction of the horse by Europeans, afterwards supplemented by firearms. The large majority of the Indians never saw a horse until centuries after the Columbian discovery. So the pastoral stage, which among the Israelites accelerated their transition from savagery to barbarism, was not experienced by the Indians; and supposing that the two bodies of people were at one time equally advanced in culture, it might well have required three thousand years longer for the Indians to reach the stage in which they were discovered than for the Israelites to have arrived at the culture shown in the days of the Judges. At the time taken for proper comparison, both peoples were living under the clan or totemic system.

A clan is a body of kindred in which kinship is established by laws now long disused, and so strange to our present ideas as to be comprehended with difficulty. Some of the more salient features of the system appear in the division of the people into tribes interpermeated by the clans, with special rules of government, adoption, protection, punishment, property and marriage.

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The totemic stage was first intelligently noticed, and yet has its typical representation, among the aborigines of America and Australia. Among the latter it is called kobong. An animal or a plant, or sometimes a heavenly body is connected with all persons of a certain stock, who believe that they are the descendants of it as their totem, their protecting daimon, whose name they bear. The line of descent is normally from the mother. When a clan becomes dominant its totem daimon may come to command the worship of all the clans or tribes in the group, the other gods becoming subordinate.

The clan system lately found in actual force in two large geographic divisions of the world has preserved a clue to the mouldered maze of man's early institutions. What is known of the clans, tribes and league of the Iroquois explains what, until recently, was mystical about the tribes of Israel.

Each clan or tribe had a badge or totem from which it was named, generally an animal, as eagle, panther, buffalo, bear, deer, raccoon, tortoise, a snake or a fish, but sometimes one of the winds and other noticeable phenomena.

The Israelites had their standards. It is not probable that the blessings of Jacob and of Moses, referring to them, were merely metaphoric. In the former, Judah is named as a lion, Issachar as an ass, Dan as a serpent, Naphtali as a hind, Benjamin as a wolf, Joseph as a bough. In Moses' blessing four of such names occur—Ephraim as a bullock, Manasseh as a bison, Gad as a lion, and Dan as a lion's whelp. The inference is strong that these were the leading totems in the several tribes, and the slight disagreements in the lists may be accounted for by the fact that the head clan in Dan had changed in the interval.

David seems to have belonged to the serpent stock. The most prominent among his ancestors bore a serpent's name. Some circumstances in his life show his connection with a serpent totem.

Critics have doubted whether Moses was so opposed to idolatry as asserted later, for a brazen serpent, perhaps an ancient idol of Jahveh, said to have been set up by him, was in existence until the reign of Hezekiah who broke it into pieces. It is true that it might have been an idol of Jahveh, perhaps worshipped as a teraph, but it might have been simply a totem. The erection of the brazen serpent by Moses in the wilderness may be more consistently explained by totemism than by idolatry in its usual sense.

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Government.—The powers of Israelite rulers were conferred on emergencies and were intended to be of short duration, but while they lasted were dictatorial. The Judges were despots without a standing army or an organized government. Their selection was due neither to descent, to suffrage, to feudal investiture, nor to violence, but was from the man's superiority, his ascendancy, strength and courage. It was rare for a man thus invested with power to be deprived of it before his death.

The alliance of the tribes was loose. They seldom hesitated to war upon one another. Even after nationality had been initiated the genius of David and the magnificence of Solomon could not permanently weld them together, and doubtless they would have temporarily fallen back into the incoherent state from which the Indians never emerged but for the late and conservative establishment of Jahvism which the Indians did not have.

The characteristics of the Israelite and of the Indian, as of the Homeric Achæans, were predatory—the tribe and its clans, with their alliances, against the rest of the world.

In the investigation of totemism among the Israelites it is important to compare its continued existence in Arabia because the state of society there remains more primitive than it was in the land of Israel when the Old Testament was written.

A large number of tribes having animal names are still found among the Arabs, for instance, Lion, Wolf, Ibex, She-fox, Dog, Bull, Ass, Hyena and Lizard. The origin of all these names is referred by the people to an ancestor who bore the tribal or gentile name. Also the animal names given in the tribal genealogies are often found belonging to sub-tribes, the same animal sometimes occurring in subdivisions of different tribes, these particulars corresponding with the Indian system.

The tribes of the southern and eastern parts of Canaan had affinities both to Israel and to the Arabs. The Arab princes of Midian were the Raven and the Wolf—heads of tribes of the same names. More than one-third of the Horites, the descendants of Seir the he-goat, bear animal names; so do the clans of the Edomites. It is disputed what the real name of Moses' father-in-law was; but he had some connection with the Kenites. The list in Genesis xxxvi, is a count of tribal or local divisions and not a literal genealogy. It is full of animal names, and the antelope stock was divided over the nation in a way only to be explained on the totemic and not

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a genealogic system. The same names appearing as totem tribes in Arabia, reach through Edom, Midian and Moab into Canaan where they show local distribution, only intelligible on the assumption that the totem system prevailed there also when the first books of the Old Testament were written.

Professor Robertson Smith gives a select list of about thirty persons and towns bearing names derived from animals and plants. Dr. J. Jacobs has expanded this into one hundred and sixty such names, though their importance is considered by him to be lessened by the frequency of such names in England, forgetting, apparently, that the clan system also existed among the ancestors of the English people.

The tribe of Judah received the powerful accession of the Dog tribe, the Calebites, among whom there were many animal names.

With such facts, and the knowledge that the early Israelites freely intermarried with the surrounding nations, it is to be supposed that the totemic system of those neighbors should appear in all Israel, as was obviously the case in Judah.

The 26th chapter of Numbers gives the clans of the tribes. Altogether seventy-two clans are mentioned, and of these at least ten occur in two tribes, striking among whom are the Arodites or Wild Ass clan, found both in Gad and in Benjamin. Other clans also have animal names; the Shillimites or Fox clan, of Naphtali; the Shuhamites or Serpent clan, of Benjamin; the Bachrites, or Camel clan, of Ephraim and Benjamin; the Elonites, or Oak clan, of Zebulon; the Tolaites, or Worm clan, of Issachar; and the Arelets, or Lion clan, of Gad.

A special suggestion comes from the tribe of Simeon. In the blessing of Jacob, Simeon is coupled with Levi as a tribe scattered in Israel. There were Simeonites in the south of Judah, but they do not appear there as an independent local tribe. According to Genesis XLIX, there must have been branches of the tribe elsewhere. It would seem that Simeon remained as a divided stock, having representatives through the female line in the different local groups. When the old system was displaced, Simeon lost importance and ultimately dropped from the list of tribes. The name of the tribe was lost but not the people, as has been noticed in careful statistical examination of the Indians.

In the stage of barbarism man belongs not to himself, but to his

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clan and tribe. In civilization responsibility is personal, and there can be no crime without a criminal intent. This was not so in the clan system, so the rules of obedience, punishment and protection were peculiar.

Clan Punishment.—The Indian punishments known were death or expulsion from the tribe, the latter, from the unprotected state of the offender, being tantamount to death. The code consisted in the application of the *lex talionis*. The vengeance of blood for homicide was exacted as a clan duty. This was executed by the clan of the person killed, generally by the nearest of clan kinship, and it was required even if the death were by accident, unless condoned by payment. Among the Israelites, as among the Indians, the duty of blood revenge appears to have lain on the kin by the mother's side.

Sanctuary.—The fact that no crimes could be individual, but were against a clan by a member of a clan, rendered it necessary to have some special provision to restrict vengeance; so the right of sanctuary, which appeared later as a prerogative of religion, was in its origin sociologic.

The avenger of blood among the Indians generally had the right to slay the criminal if found within a specified time, such as two days, after the act; but if he should escape that long the avenger could no longer pursue and was himself liable if he should persevere. The clan at that stage interfered, and there were among some tribes localities (called by Adair the "Cities of Refuge") designated, in which the criminal should be safe from minor offences until the general wiping-out of vengeance at the next annual festival. Compare Numbers xxxv, 12: "And they shall be with you cities of refuge from the avenger, that the man-slayer die not until he stand before the congregation in judgment."

The functions of the avenger of blood are only referred to in the Pentateuch, but were well known in ordinary cases. The law treats of the exceptional circumstances of an accidental homicide. There is a trace, in Deuteronomy xxiii, of the general communal sanctuary in Israel. It enacts that any town or village shall be an asylum for an escaped slave. In Exodus xxi, the altar (presumably any one of the numerous village altars) is mentioned as a refuge. In the cities of refuge the sanctuary was used only for the mitigation of the revenge of blood, as Israel retained the old *lex talionis*.

A mode of bringing to notice the barbarian stage of the Israel-

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ites at the time mentioned, is to translate into English familiar personal names from the Old Testament, such as the Dog, the Dove, the Hyena, the Lion's Whelp, the Strong Ass, the Adder, the Running Hind. This brings into immediate connection the English translation of Indian names, such as Big Bear, White Buffalo, Wolf, Red Cloud, Black Hawk, Fox, Crow and Turtle. It is possible that in addition to gentile derivations (for the Israelites in that sense were Gentiles), a reason for the adoption of such names was that they could be represented objectively, as is certainly the case among the Indians, who possess very few names that cannot be represented in pictographs; and the very large topic of tattooing is connected with this device antecedent to writing. The compilers of the Old Testament probably desired to break down a former practice as is shown in Leviticus XIX, 28: "Ye shall not print any marks upon you." And there are other similar indications.

Adoption.—The early history after the exodus shows many cases of adoption from among the neighboring tribes, in which the captive or the stranger adopted became a member of one of the clans for the same reason as among the Indians, as otherwise he could have no status.

Caleb is first known as the son of Jephunneh, the Kenezite. Next he appears as a chief of the tribe of Judah; finally, in the book of Chronicles, his foreign descent is lost. He becomes Caleb, the son of Hezron, the son of Judah. This is an instance of adoption and is not contradictory, as Caleb could have no place in the tribe except by adoption. He is first described in accordance with the actual facts of his descent, but when adopted with his family and followers forming probably a sub-clan, he would be called by the name of the family that adopted him.

The whole population of the country which, according to Deuteronomy, was to have been exterminated, slowly became amalgamated with the invaders. In this way alone their rapid increase can be accounted for.

Not until the late prophetic influence was the doctrine established that no quarter should be shown to the enemy and no alliance made with the Goim, a word meaning the "nations", with the implication of "heathen", the use of which dates from the ninth century B. C. It is gratifying to believe that the stories of the wholesale extermination and cruel outrages injected into the historical narrative were afterthoughts intended to be examples for

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the future and that they never occurred in fact. Otherwise the brutality of the Israelites to the conquered would have been more horrible than that of the Indians among whom captivity was tempered by adoption.

An interesting custom of the Indians connected both with the rite of sanctuary and that of adoption is that when captives had run through what was called by English writers "the gauntlet" to a post near the council house, they were for the time free from further molestation. It is possible that in the northeastern tribes this was in the nature of an ordeal to discover whether or not the captive was vigorous and brave enough to be adopted into the tribe; but among other tribes it appears in a different shape. Any enemy, whether or not a captive, could secure immunity from present danger if he could reach a similar post, or if there were no post, the hut of the chief. A similar custom existed among the Arikara who had a special pipe in a "bird-box". If a criminal or enemy succeeded in smoking the pipe contained in the box he could not be hurt. This corresponds with the safety found in laying hold of the horns of the altar.

Land.—In the earlier history of the Israelites there could be no individual property in land—it belonged to the clan as it did among the Indians. When arriving at sedentary and national life an expedient was invented to compromise the permanent possession of land by the clan, with individual rights of occupancy, which would allow of a proper stimulus for improvements. This was done by the institution of the Sabbatical year, or the year of Jubilee. The Indians, not having reached the sedentary stage (except in rare instances), were not obliged to invent that device. The similarity remains, therefore, that no man could acquire an absolute property in land. The title was not in him but in his clan.

Forbidden food.—The Indians long observed a prohibition of eating any part of the animal connected with their totem, and of course also of killing it. For instance, most of the southern Indians abstained from killing the wolf; the Navajo do not kill bears, the Osages never killed the beaver until the skins became valuable for sale. Afterwards some of the animals previously held sacred were killed, but apologies were made to them at the time, and in almost all cases a particular ceremony was observed with regard to the reservation of certain parts of those animals from food, on the principle of synecdoche, considering the part to rep-

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resent the whole, the temptation of using the food being too great to permit entire abstinence. The Cheroki reserved the tongue of the deer and bear from food, which they cut out and cast into the fire. An instance, reported this year as still existing among the Ojibwa, is in point, where there is a formal reservation, yet by a subdivision among the same clan, an arrangement is made in which subclans may among them eat the whole animal. A bear is killed; the head and paws are eaten by those who are one branch of the bear totem, and the remainder is reserved for others. There is a a common differentiation in which some persons can eat the ham and not the shoulder and others the shoulder and not the ham of certain animals.

The Egyptians did not allow the eating of animals that bore wool. This is attributed to the sacred character of the sphinx, and has other religious connections. It is supposed by some writers that the legislation of Moses with reference to forbidden food, was to antagonize social union with the Egyptians by permitting to the Israelites articles not used by the Egyptians, and *vice versâ*. It is true that some forbidden food of the one nation was allowed to the other, but the abstinence of both from swine is not consistent with the hypothesis.

The survival of totemism may be inferred from the lists of forbidden food in Leviticus XI, and Deuteronomy XIV. It would appear that about the time of the exodus the Israelites were organized on the basis of families or clans tracing through female lines, and named Hezir (swine), Achbor (mouse), Aiah (kite), Arod (wild ass), Shaphan (coney), and so on. Each of the clans refrained from eating the totem animal or only ate it sacramentally. As the totem organization declined, the origin of the abstinence would be lost, but the custom lasted, and when the legislation was codified it was incorporated in the code. The hypothesis would explain certain anomalies in the list; *e. g.*, coney, or rock badger, for which no other deserving attention has been given. The division into clean and unclean food by the two tests of cloven foot and rumination was a later induction from the animals regarded as tabu. This is confirmed by the want of any systematization in the list of birds given in Leviticus.

It would be expected that animal names were connected with the animal worship before mentioned, and there is some evidence that men, bearing a common animal stock name, though in different

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tribes or nations, recognized a unity of stock. Our most definite information on the subject is derived from Ezekiel, chapter VIII, where there seems to be an account in which the head of each house acted as priest, and the family or clan images, which are the objects of idolatry, are those of "unclean" reptiles or quadrupeds, *i. e.*, those which are prohibited from use as food. It is true that the argument of Professor Smith on this subject is controverted by Doctor Jacobs, but only as to the survival, not as to the early existence of the cult.

No one has yet given a satisfactory theory of the Israelite division between clean and unclean animals, apart from the explanation afforded by the totemic system. No rational motive can be assigned for the avoidance of certain animals, in themselves hygenically good. The explanation that swine's flesh was liable to bring disease, and therefore was prohibited for a sanitary reason only, covers but a small part of the subject and is not in itself satisfactory. The meat of the hog is, in fact, as wholesome in Syria as it is in Cincinnati, and the medical conception of trichinosis had certainly not arisen in the times under consideration. The avoidance of all meat, indeed of all food, for purposes of fasting and producing ecstasy, is in a different category and has already been mentioned.

Marriage.—The laws of marriage in the stage of barbarism are intricate, but attention may be directed to a few points which strongly distinguish its features from those in civilization. Its most general characteristic is that it was strictly by legal appointment. The levirate, named from the word levir, a husband's brother, is in brief, the practice by which it is the combined right and duty of a brother—often the eldest surviving brother—to marry the widow of his deceased brother. Prof. E. B. Tylor reports that this practice appears among one hundred and twenty peoples; *i. e.*, in about one in three of the distinct peoples of the world. It was almost universal among the Indians, sometimes with additional duties and privileges. A widow, as a rule, could not marry any one but her deceased husband's brother except on his refusal or after a long time of mourning.

In several tribes the marrying of an elder sister gave rights over all the others; and sometimes the son-in-law, especially when he married the eldest daughter, became entitled to all the property of her father, and also the younger sisters of his wife if he chose.

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Other men could not take them until after his refusal. This right to all the unmarried younger sisters sometimes continued after the death of the first wife. Not unfrequently a man married a widow and her daughters at once.

Among the Israelites it was common to have several wives of equal status, who often were sisters. A widow had a right to appeal to her brother-in-law, or some member of her husband's family, for a second marriage, and an evasion of the duty was a gross offence. Deuteronomy xxv shows the degrading terms of the formality by which the brother-in-law was freed from the obligations of marriage and the widow allowed to marry another man. Judah admitted that Tamar's conduct was perfectly correct. It was but a legitimate extension of the levirate law.

There is the clear statement in Leviticus that the Egyptians and the Canaanites formed such marriages as with them were connected with the totemic system but by the Israelite law were made incestuous. The laws of incest given in Leviticus are probably later than the code of Deuteronomy where the prohibition is directed against marriage with a man's father's wife. This precept denounces the practice in Arabia by which the son inherited his father's wife as his property.

In the framework of the Deuteronomic code there were three prohibitions: father's wife, sister, and wife's mother. To these offences Ezekiel adds marriage with a daughter-in-law. All those forms of quasi-incest were, according to the prophets, practised in Jerusalem; and the history seems to show that all were once recognized customs. The taking of a father's wife was not wholly obsolete in the time of David.

As regards the Israelite descent in the female line, it may be noticed that the children of Nahor by Milcah were distinguished from his children by his other wives. Rebekah's descent is practically valued as a descent from Milkah, and the family or clan connections is traced entirely through Milkah and Sarah. Moses' father married his father's sister; Nahor married his brother's daughter; Abraham married Sarah, the daughter of his father but not the the daughter of his mother.

A passage in Judges relates to exogamy, recording that Ibzan had thirty sons and also thirty daughters whom he sent abroad, and took thirty daughters from abroad for his sons. Exogamy, however, could not be kept up when the Israelites became mainly an

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agricultural people, and in the times of the kings only survivals of it remained.

Mr. Fenton, in his acute remarks upon the story of Lot's daughters, has not exhausted the subject. It was not only the fact that according to the clan system it was proper for Lot to marry his daughters, but under the circumstances it was obligatory upon him to do so. The logical propriety of the marriage of a father to his daughters, on the ground that they did not belong to the same clan, is clear, and the practice exists to-day among a number of the tribes of Indians not much affected by European influence. A father was not of kin to his own children. They belonged to the mother's clan, and not to his. An interesting example of this clan law is narrated by Dr. George M. Dawson as still existing among tribes of British Columbia, where a rich Indian would have nothing to do with the search for his aged father who was lost and starving in the mountains. Not counting his father as a relative, he said, "Let his people go in search of him." Yet that son was regarded as a particularly good Indian.

There are other instances where the son would fight against the father to the death. Such cases would occur where a son married, necessarily, a woman of another clan, and went to live with her people, and when there was warfare between her clan and that of his father, he was by association expected to fight against the latter, there being no reason why he should not.

It is, however, true that, in a large number of tribes of Indians, the marriage of father and daughter has been, during the time of European examination, very rare. It may be suggested as a reason that a gradual change has occurred from the mother-right to the father-right, in which the attitude is reversed; but practically the fact that, either the father or mother, by treating the daughter as an object of value or merchandise, could secure presents from the suitor, would have tended to break down this part of the clan marriage system before any other, and, the custom ceasing, the practice became wrong. So it is true to-day among Indians, as it was in a much more marked degree at the time of the compilation of the existing version of the Old Testament, that the marriage of a father and daughter is reprobated. In this connection it is interesting to notice that the Navajo have a myth, undoubtedly native, that in the old time one of their race took his daughter to wife

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and their offspring became the ancestor of the Utes, the hereditary enemies of the Navajo. This is a parallel with the stigma inflicted upon the Moabites and Ammonites who were the descendants of Lot and the enemies of the Israelites who wrote the history but yet were recognized by the latter as of the same stock.

The part of the story of Lot which tends strongly to show its later manipulation, is that the authors of the version, having at that time the idea of a horrible incest, explained that the good man, specially so designated by tradition, was guilty of it only because he was unconscious through intoxication. They were obliged in accordance with one tradition, to make him the ancestor of Moab and Ammon; from another tradition they had him left without any sons and no wife, the two daughters being all of his family who survived the destruction of Sodom. They used their materials, therefore, with the excuse of intoxication, but there was no occasion for such excuse. In the age to which the tradition related, the transaction was perfectly proper, does not involve sexual passion, and was required by law to keep up the stock, but the clan rules had been forgotten when the book of Genesis was written.

In the stage of barbarism the marriage of brother and sister was common all over the world. Where polygamy existed, as was the case among the Israelites, and probably among all the Indians, a man could not, according to the rules of the gentile system marry into his own clan. If he took several wives it is probable that they would sometimes be of different clans not only from his own, but from one another. In such cases the child of the wife of clan A was not of the same clan as the child of the wife of clan B, and they could marry. The marriage of uterine brothers and sisters was not consistent with the clan rules.

Writers on the subject of the clan system have extolled it as being profound with physiological insight to prevent inbreeding; but the best and latest physiologists doubt that inbreeding is bad unless there is a taint of blood which should prohibit the marriage of either party to any one, and a true understanding of the clan system would have shown that as it certainly permitted marriage between a man and his half-sister, and with his aunt, his father's sister, if not the more violent case of father and daughter, it did not accomplish the object lauded.

The late prohibition of a man's marriage to his deceased wife's

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sister cannot be maintained on any principle of physiology or sociology. It is a blunder that perhaps arose in the transition stage from the matriarchate to the patriarchate system.

CONCLUSIONS.

It has often been asserted that the Semites, and specially that branch of them lately styled the Syro-Aramæans, were specially adapted to a spiritual religion; that monotheism was in their racial constitution; that whether through revelation or because they were well adapted to receive such revelation, their idiosyncrasy directly led them to spiritual ideas, which to modern minds means monotheism. This was not the record of the historical books of the Old Testament, even after their manipulation. The prophets of Israel declared the exact contrary; they denounced their own people as rejecting spiritual proof and as not deserving the favor of Jahveh. This declaration is confirmed. The beliefs and practices of the Israelites were substantially the same as those of other bodies of people in the same stage.

The Israelites were not a "peculiar" people. There is, racially, no peculiar people in the sense intended. Mankind is homogeneous in nature though placed in differing and ever advancing grades of culture. What has been called blood in a racial sense may be likened unto the water of the earth;—as it comes from the clouds it is chemically the same, and it is subjected, wherever it is, to the same laws. The early course of a rill may be turned by a pebble, and from the elevations and depressions met it may become a lake or a river, or a stagnant marsh. From the character of soil encountered it may be clear or muddy, alkaline, chalybeate or sulphurous. In one sense, which belongs to modern and not to ancient history, the Jews are a peculiar people, from the fact that for many centuries, until lately, they proclaimed themselves to be such and observed religiously the doctrine about the Goim, and therefore did not intermarry with other peoples; but this also has been from the fact that persecution made them pariahs and the other peoples would not intermarry with them. The so-styled purity of their race has been kept up by isolation during the recent centuries, but the assumption of great purity in the stock at the Christian era is not tenable, and now that their prejudices and those against them are dissolving, it is probable that what has been improperly called the Jewish race will disappear by absorption in precisely the same man-

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ner that the Indians are now disappearing. To renew the simile, they both will be lost in the homogeneous ocean which all mankind seems destined to swell.

I do not enter upon the controversy respecting the races of mankind except to confess, as the sum of my own studies on the subject, that all attempts at the classification of races have failed. The best generalization may be taken from the address of Professor Flower to the Section of anthropology of the British Association for the Advancement of Science: "I am compelled to use the word race vaguely for any considerable group of men who resemble each other in certain common characters transmitted from generation to generation." The most useful mode for the examination now of peoples by anthropologists is not by attempts at racial divisions, but by the determination of their several planes of culture with the recognition of specific environments. Admission of this fact is practical. The most sensible remarks ever made by missionaries were those of the Rev. Messrs. Lee and Frost who, after ten years in Oregon of what has been considered successful work, announced their abandonment of their former belief that if the heathen were converted to Christianity civilization followed of course. They confessed that civilization must begin before Christianity could even be understood. Acute travellers throughout the world have perceived the same fact, and it is not a too violent simile to say that Christianity, belonging to the plane of civilization and to that only, sits on a savage or barbarian as a bishop's mitre would on a naked Hottentot.

Moses did not change the Israelites from their barbarian condition. It was not possible. As regards the culture strata we may take a lesson from geology. Coal is not found in the Silurian formation, therefore wise miners do not look there for coal. The higher mammals are not found earlier than the Cenozoic, though their precursors are in the Jurassic. Let us look in the savage stage as if it were Jurassic to understand and trace what we may afterwards find in the barbarian or Cenozoic, and developed later in the present epoch; but to search for the complete ideas of civilization in the period of barbarism would be as sensible as to dig for manuscripts among the workshops of flint arrowheads.

There is a Rabbinical legend that Lot first argued the existence of one god ruling the universe, from the irregular phenomena observed on land and sea and among the heavenly bodies. "If these

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had power of their own," he said, "they would have had regular motions, but as they had no regularity they were subservient to the occasional exercise of a higher will." With greater scientific knowledge these supposed irregular motions are now embraced within laws considered to be permanent, if not immutable; but the existence of such tremendous laws gives a higher conception of their maker. Their suspension or violation is not in accordance with human reason, and mere suggestion of such variations clouds the glory of divinity.

The doctrine attributed to Lot is instructive, because its conception of nature permeated all the early philosophy. We now define a miracle specifically as a deviation from the laws of nature. But to those for whom nature had no laws, the prime definition as "the wonderful" was alone correct. A supernatural being could, and was expected to, do anything whatever in accordance with his arbitrary will, and men who were inspired or empowered by the supernatural were also expected, in fact required, to work wonders. It would hardly be a paradox to assert that the supernatural was alone natural and that in the explanation of phenomena only the irregular was regular.

The order of the evolution of revelation, as may be appreciated by every student regarding all revelations but that one which he credits, is that some practice existed early for which a natural explanation may be made. This practice became a formal custom which, after a time, was considered to be obligatory under the vague but compelling idea that it is "bad luck" not to observe it. Bad luck is necessarily connected with the supernatural, therefore the custom or the series of customs became a religion, and that was always explained at a later time by a myth which was not necessarily an explanation made by imposture or fraud, but grew from the curiosity of men and their hurry to account for everything. All such myths are declared to be obtained, through revelation, from a power higher than man. The result is, therefore, that revelation, which is the last step in the evolution of religion, is enounced by antedating, to be the first step. When revelation is once admitted, man's mind clings to it as a refuge from doubt which always must attend the results of reasoning on subjects not admitting of demonstration. Such clinging becomes fanatical with most men because they dread as the greatest injury to be cast into the hands of the Giant Doubting who for them is but another name for Giant Despair.

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There is also a sentiment involved that the old thought, that of the ancestors, is always the best. This is incorrect unless on the theory that all knowledge comes from revelation. The continuance of the old is bad because it is old and is maintained through superstition in the true etymological sense of the word. Some advocates of the old reject all new thoughts, but the more intelligent attempt to force a reconciliation. What they believe now must be right. What they are not accustomed to is shocking, therefore is wrong. So the old, which was always right, must be distorted to contain in it the new which also is right, and what there is in the old that cannot be managed otherwise must be explained away.

An apparent exception to the unfitness of old direct teachings is where there has been a general degradation in culture after which a return to the results of the former and forgotten culture is most desirable. This is illustrated in the revival of learning after the dark ages in Europe when the classic writings as discovered and studied brought new illumination to the world. But this was a simple readjustment of sequence after a hiatus. The advance of development, not chronology, makes the proper criterion. The archaic is that which is nearest the beginning of human life. We have the history of the Israelites for forty centuries; we have that of the Indians for little more than three centuries; yet though the Israelites advanced in recorded times beyond the plane of the Indians, who shall say which of these was the older people?

He would be both silly and malicious who should impugn my treatment of the present subject as a direct or covert attack upon the books of the Old Testament. On the contrary, I regard that noble work as the most important anthropologic record possessed by man, richly repaying such study and comparison as all valuable records demand. I gladly accept it as a genuine account, and believe that though it has been colored by time and by the work of man, it never was invented, and is not to be treated as a literary or religious fabrication. It is asserted that some persons occupied in science fear or pretend to scorn the Bible. I do neither. I admire it, and study it, and gain much from it; but no intelligent persons take as of the same authority all its versions or indeed all the contents of the books arbitrarily styled canonical on the very names and numbers of which churches and sects dispute.

The Hexateuch contains the same intrinsic evidence of truth as was obvious to the Ojibwa, before mentioned, who said that the

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work was true because they and their fathers "had heard the same stories since the world was new." To those who can read it understandingly it is a true story of a plane of culture. But when we find that distinct revelations have been and are claimed by all the tribes of men in that plane of culture we are forced to recall the words of the sage who gave as the reason for his disbelief in ghosts that he had seen too many of them.

"Now as to myself I have so described these matters as I have found them and read them, but if any one is inclined to another opinion about them, let him enjoy his different sentiments without any blame from me."

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PAPERS READ.

SOME PRINCIPLES OF EVIDENCE RELATING TO THE ANTIQUITY OF MAN. By W J McGEE, U. S. Geological Survey, Washington, D. C.

[ABSTRACT.]

THE principles of evidence relating to the antiquity of man may be summarized in a series of propositions which it is the object of the paper to discuss. The primary propositions are: 1. It is a fair presumption that any artificial object found on the surface is modern; 2. It is a fair presumption that any stone object of doubtful origin is natural; 3. It is a fair presumption that any unusual object found within, or apparently within, an unconsolidated deposit is an adventitious inclusion; 4. It is a fair presumption that an isolated association is adventitious; 5. It is a fair presumption that an incongruous association is adventitious. These presumptions may be outweighed by direct or collateral evidence, and indeed have been so outweighed in all of those cases which prove a high antiquity for human kind; but in weighing such direct or collateral evidence, certain additional and more general principles must be recognized. The more general propositions are: 1. In inductive science the value of evidence varies with its volume, its consistency, and its cumulative character; 2. In inductive science the sufficiency of a given body of evidence varies inversely with the importance of the conclusion to which it leads; 3. In inductive science every conclusion is tentative; 4. In exact knowledge the sufficiency of evidence and the validity of conclusions vary inversely with the exactitude of the branch of science affected.

POINTS CONCERNING THE LITTLE FALLS QUARTZES. By Miss FRANC C. BABBITT, of Coldwater, Mich.

[ABSTRACT.]

THE Little Falls quartzes to be considered in the present paper are strictly limited to the implements and chips found by the writer, in 1879, upon the east shore of the Mississippi river, at Little Falls, Morrison county, central Minnesota. These quartzes were taken from an implement-bearing

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stratum a few inches in thickness wherever examined, lying about fifteen feet below the actual surface; and they are not to be confounded with the quartz pieces distributed through the upper soil in the immediate vicinity, described by the state geologist, Prof. N. H. Winchell, in his sixth annual report.

A point fundamental to any fruitful study at large of these objects is the essential one: Are they genuine palæoliths? The inquiry formulates a dual problem in origins—origin as to agency, and origin as to time. Leaving out of the account the minor differentiations nascent in American palæolithics, the general question involves, in the present case, these two: Were the Little Falls quartzes shaped by man? Were they produced prior to the close of the last glacial epoch? The two inquiries naturally address themselves to two quite distinct departments of science, namely, archæology and geology.

In accordance with this view of the matter, and at the suggestion of the state geologist of Minnesota, the quartzes indicated were early submitted to authorities upon the primal productions of the human race, for an ultimate decision as to their artificial character. The subject of their relative antiquity was meantime referred to specialists in the quaternary geology of the region. Parcels of specimens have found their way at different times to various scientific institutions, and have likewise been supplied, for purposes of study and comparison, to distinguished archæological experts, as to Dr. Charles Rau, to Dr. C. C. Abbott, and to Professors Haynes, Putnam and Mason.[1]

With the exception of Dr. Rau, deceased, whose final conclusions were not communicated to me, the authorities named concur, as I have been assured, in declaring these quartzes to be the unmistakable product of intention; either as chips struck off in the process of manufacture, or as imperfect or finished implements. Certain of the latter have been identified with well-known types, their assimilation to which is regarded as essential and not fortuitous, and as indicating that the widely scattered palæoliths of this continent and the other had a common *raison d'etre*. Let it be understood, therefore, that the artificial character of the specimens in hand is not established upon my own personal *ipse dixit*, nor that of any other individual, but upon the unanimous verdict of qualified scientists of international repute. As these authorities are equipped with special facilities for comparison, and have an intimate acquaintance with objects of the class discussed, there appears to be no sound reason for distrusting their matured opinion. Professor Putnam has, at different times, brought typical specimens of these objects before the Boston Society of Natural History for general examination and comparison with other palæolithic

[1] Dr. Rau turned over to the Smithsonian Institute the specimens forwarded for his inspection; Dr. Abbott placed those in his keeping in the Peabody Museum of American Archæology. The objects exhibited before section H, of the A. A. A. S. at its Minneapolis and Philadelphia meetings of 1883 and 1884, together with others submitted to examination by Professor Haynes, have been consigned to the same institution.

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implements, American and foreign. In the proceedings of this society for the present year, pages 164–5, he presents figures of Little Falls quartzes, of which he says:—"Others of these before you are identical in shape as well as material with the specimens obtained by Dr. Abbott from the Trenton gravel, and certainly their artificial character will not be questioned." Professor Haynes, in the chapter on Prehistoric Archæology of North America, in Vol. I of Winsor's Narrative and Critical History of America, expresses a like opinion, formed upon the study of numerous specimens that have been submitted to him, but not the same as those upon which Professor Putnam has based his conclusions.

THE QUARTZ STRATUM AN ARTIFICIAL FORMATION.

Prior to the actual test of the Little Falls quartzes by comparison with others, certain peculiarities of their accumulation led to the conjecture that they had been posed in their present bed through design, and that a portion of them had been used by man, whether they had received shape at his hand, or not. The quartz stratum as a whole appeared to be an artificial formation, quite irrespective of the particular origin of included individual specimens. This was shown by its mode of deposit, its general composition, and the assorted condition of its contents.

First, the quartzes seemed to have been deposited originally upon dry land, and by other agency than water. This was indicated by peculiarities in their occurrence. Thus they were not distributed promiscuously through the modified drift, in the manner of those reported by Professor Winchell as scattered through the soil where "large trees tear it up." They were, on the contrary, compacted in a thin, nearly horizontal stratum having definite upper and lower planes. They were moreover conspicuously unwaterworn. The ancient surface supporting this stratum differed slightly from the overlying deposit both in color and composition, being somewhat more clayey than the latter. Its stony constituents were also rather more waterworn and graduated rapidly downward into increasingly coarse and abundant pieces—facts finding explanation in Mr. Warren Upham's statement of the relations existing between the retreating ice-sheet of Minnesota and the Mississippi river-gravels at Little Falls.[1] The surfaces of the deposit were so uniform that when the hand, intruded horizontally, was raised or lowered by only a few inches, the supply of quartzes wholly failed. Had they been transported hither by water, either when their present sandy bed was dry land or the soft bottom of a river or pond, they would presumably have been more or less diffused through associated material, would have penetrated the underlying gravels confusedly, to varying depths, and would present many waterworn surfaces. These conclusions were by no means purely conjectural, but were based upon the

[1] Palæolithic man in eastern and central North America. The Recession of the ice-sheet in Minnesota in its relation to the Gravel Deposits overlying the Quartz Implements found by Miss Babbitt at Little Falls, Minn., Warren Upham, p. 436. Reprint from Proceedings of the Boston Soc. Nat. Hist., Vol. XXIII.

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present behavior of such fragments under similar, though less rigorous conditions.

Second, the composition of the stratum supported the same view. It was made up of a multitude of quartz chips and splinters and, resting upon and among these, thousands of larger pieces, numbers of which have since been identified as implements. In illustration of the immense quantity of the larger fragments I may repeat that, at one time, I collected of them for study, by actual count, about one thousand pieces which had been newly washed out by the rains, while leaving probably some hundreds stranded among the stones in their pathway, or enveloped in the subjacent sands. Yet this did not diminish the average yield of the stratum beyond the immediate margin of erosion.

These quartzes were unlike the indiscriminate product of long-continued disintegation, not only in their vertical limitation, but also in their shape and their very moderate size; none of them being too heavy to be carried easily in one hand. Much the largest of the whole were scattering specimens weighing two or three or more pounds. Judging from their form, these might have been utilized as pounders or weapons. With the single exception of a small waterworn quartz bowlder which was not included in the stratum but which, as inferred from its position, might once have been so, no mass greater than these was found during an investigation continued at intervals down to 1885.

Third, the assorted condition of certain of the specimens supplied proof positive of human interference, While some particular forms, as pounders and the like, were scattered through all parts of the deposit, others occurred only, and others still mainly, in groups each of which represented a particular type of specimen. These little clusters most frequently occupied a surface of only a few square feet. They appear in every part of the stratum explored. Each group, besides the ordinary debris, contained one or two, or sometimes, a considerable number of relatively perfect specimens associated with others less differentiated in shape which were perhaps spoiled and unfinished implements. Occasionally also some single group comprehended quite distinct modifications of the primal type. Thus among the first recognized implements of the place were a few plano-convex specimens corresponding in shape with those originally figured by Dr. Abbott as *turtle-backs*. In close proximity to these, appeared pieces having the same general contour, but apparently spoiled by the loss of too thick a flake; others which were probably unfinished; others with one extremity differently shaped; and others still presenting two convex surfaces.

From the above premises it was at length concluded that the quartz stratum represented an ancient work-site of man. A peculiar distribution of certain choice varieties of material, together with the unmistakably worn condition of edges and angles of occasional specimens, further corroborated this theory.

The process of inhumation must have been a most gentle one, undisturbed by the action of currents; a fact to which we no doubt owe the singularly perfect preservation of this mass of remains. It is as though

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the infant Mississippi had formed a lake-like expansion at Little Falls, perhaps through encountering some obstacle at the south. It appears not improbable that the quartz-workers were driven from this spot by the encroaching waters. We cannot suppose them to have abandoned their industries and properties here, except upon necessity, real or supposed, nor would they have been likely thus to assort their belongings but with the prospect of repossession.[1]

GLACIAL ORIGIN OF LITTLE FALLS QUARTZES.

The glacial origin of the Little Falls quartzes is, strictly speaking, not a matter at issue. So far as I know, it has never been questioned by competent geological authorities that the including formations belong to the last ice-age. Mr. Warren Upham, who has devoted six summers to a personal examination of the region, concurs with the state geologist upon this point. He says:—

"My observation and study of that region convince me that the rude implements and fragments of quartz discovered at Little Falls were overspread by the glacial flood-plain of the Mississippi river, while most of the northern half of Minnesota was still covered by the ice, contemporaneously with its formation of the massive moraines of the Leaf hills and with the expansion of Lake Agassiz on their west side, respectively sixty and eighty-five miles west of Little Falls."

In his admirable monograph, Mr. Upham states the conditions rendering possible the occupation of this spot, and those causing its abandonment. I take leave to condense from this publication such results of his research as are necessary to a clear comprehension of the present case.

As shown by Mr. Upham, that portion of the last great glacier which extended across Minnesota from north to south ended in a vast ice-lobe descending at its utmost southern limit to the neighborhood of Des Moines, Iowa, and forming there the Altamont *terminal* moraine. During its retreat thence to the northern boundary of Minnesota, there ensued ten distinct periods of halt, or perhaps of re-advance, defined by as many *marginal* moraines extending in irregular east and west curvatures across the country. Three of the eleven moraines have their extreme terminus in Iowa, the remaining eight in Minnesota. The seventh halting-place, proceeding northward, was at the Dovre moraine, the south-east shoulder of which rests upon Kan-da-*yo*-hi county, some distance below Little Falls. In its recession thence to the eighth and ninth moraines lying to the north, the glacier disappeared entirely from the Little Falls river-basin, leaving behind it the present underlying sheet of till.

The two last mentioned moraines are merged in one at a portion of their course known as the Leaf Hills. This range projects southward from Fer-

[1] "Description of some palæolithic quartz implements from central Minnesota," Section H, Proceedings of A. A. A. S., 1884. "Vestiges of glacial man in Minnesota," American Naturalist, 1884, June, July numbers. "Ancient quartz workers." American Antiquarian, 1880, Vol. III, No. 1.

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gus Falls in a semicircle stretching fifty miles to the east, and attaining its extreme southern limit, "nearly due west of Little Falls and half-way between the south and north borders of Minnesota." From each extremity of this common range, the eighth and ninth moraines diverge as independent formations. Eastward, the eighth, or Fergus Falls moraine, has been correlated with conspicuous hills in Morrison county, five to fifteen miles from Little Falls, measuring to the east, north and west. The ninth or, as it is called, the Leaf Hills moraine, stretches across the northwest of Morrison county and proves the originating glacier to have stood at its nearest approach only twenty miles distant from the quartz stratum.

Mr. Upham further shows that the modified drift underlying the bed of remains and resting upon the till was deposited by floods from the melting ice-sheet, when at its eighth halting-place, and that the superior accumulations were brought down and spread out during the period of retreat immediately following.

GLACIAL RÉSUMÉ.

In *résumé*, the above order of events is as follows:

First.—The ice-sheet, after a withdrawal northward of something like three hundred miles, made a seventh halt at the Dovre moraine, below Little Falls. A further retreat to the eighth moraine, lying above it, left the river-valley divested of ice but covered with a sheet of till.

Second.—The floods issuing from the melting glacier, at its local terminus among the Morrison county hills, spread out the debris at its base upon the till forming the bed of the Mississippi, here and then, about three miles in width. Eventually the floods decreased; the river deepened its channel; lateral portions of the river-bottom became flood-plains.

Third.—The Little Falls man set up his industries upon the surface thus made ready. As suggested by both Winchell and Upham, he probably established himself here because of the quartz veins in the vicinity, no satisfactory outcrop of the mineral appearing in Minnesota south of this place.

Fourth.—At the period of glacial recession immediately succeeding, the floods again overflowed the river-plain, and with their finer deposits sealed up the site and the product of the quartz-worker's labor.

SIGNIFICANT POINTS OF THE LITTLE FALLS QUARTZES.

These remains have possible phases of significance not yet, perhaps, fully apprehended. It is a mooted question with archæologists whether the man of the drift followed up the melting glacier to the north, The quartz-workers, supplying a case in point, answer the inquiry so far as can be done by a single example. They had pushed their way to the very foot of the ice-mountain when it stood three hundred miles north of its original terminus in Iowa. They dwelt here for at least a portion of the year at a time when the Leaf Hills were in accumulation only sixty miles to the west, when the glacial Lake Agassiz was at its maximum height eighty-

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five miles to the west, and when the Minnesota glacier had already withdrawn half-way from its southernmost limit to "the district across which the Nelson river flows to the Hudson bay." The prehistoric page opened to us by this quartz-working folk is chiefly however a page of questions. Did the race thus haunt the outskirts of the great ice-fields from choice? Had it, during the long ages of glacial encroachment, so acclimated itself to frigorific conditions as to prefer them? Or was it crowded northward by hostile drift-men on the south? What were its powers and habits of locomotion? Did its members, like birds of passage, flit from south to north and back again with the seasons? If not, were they endued by nature with a covering of hair, or had they already learned to protect their bodies with the skins of beasts?

If, as suspected, the primal savage developed skill in his ancient habitats, we should for obvious reasons be prepared to find possible traces of advancement in the northern branches of the race. Among the first progressive steps of primitive man would be such modifications of his *stone fist* as would adapt it to special uses: like cutting, pounding, scraping, and thrusting. This has appeared to me to be distinctly the status of the Little Falls quartzes. According to every indication, the artificers were not solitaires. There existed among them a society in nucleus if in no advanced stage of evolution. They had plainly attained to some notion of a common interest, of ownership, and even of a sort of order.

Another progress in methods would be the adjustment of the stone fist to an arm of wood, the result being of course a compound instrument. I may observe that I could only account for certain of the quartz forms upon the hypothesis that this is their actual character. At a first glance, the theory that the quartz-workers had made any advance whatever in their handiwork seems directly opposed by the extreme rudeness of their products, a rudeness which has militated so strongly against the recognition of their work by tyros in palæoliths. Let us not forget, however, that their general workmanship represents two separate elements; the skill of the artificer, and the quality of the manipulated material. Now the Little Falls quartz veins supply a mineral many of whose natural forms require but slight modification to adapt them to the uses of savage life; and we may reasonably infer that fragments which needed but little fashioning, would receive but little fashioning. In other cases, where no small labor has been expended upon objects, the flaking process is often so disguised by the irregular fracture of the quartz as to be almost inappreciable. Such implements show the work put upon them in a far lower degree of course than those of material having a definite fracture, like the different varieties of flint and the Trenton argillite.

Because of its geographical position and other characteristics, the deposit above discussed is not unlikely to supply a basis of comparison for future palæolithic finds in the northwest. Its former contents should therefore receive careful examination with reference to possible original types. It remains also to be correlated with glacial systems on the east and the west, and to be studied in its relations to the semi-superficial quartz debris in the neighborhood.

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EVIDENCES OF THE SUCCESSOR OF PALÆOLITHIC MAN IN THE DELAWARE RIVER VALLEY.[1] By Dr. CHARLES C. ABBOTT, of Trenton, N. J.

[ABSTRACT.]

RESULTS of a careful survey of a wide extent of territory in New Jersey, in the valley of the Delaware and other rivers of the state, showing that the circumstances under which argillite implements of a neolithic type are found as a rule, indicate that such "finds" or village sites are of an earlier date than those known to have been occupied by the Delaware Indians immediately preceding and during historic times.

With exhibition of specimens.

DESCRIPTION OF A GOLD ORNAMENT FROM FLORIDA. By A. E. DOUGLASS, Museum of Natural History, New York, N. Y.

[ABSTRACT.]

DESCRIPTION of a gold gorget found on the Kissimmee river, Brevard county, Florida. Testimony to show that Florida was known at the beginning of the sixteenth century to be destitute of mines or placers of gold. Testimony of the first explorers as to the presence of gold there, and as to its probable source. Reasons for concluding that none of the gold then found in Florida could have come from North Georgia. Never found in the latter state by the earliest expeditions therein, either in use among the natives or in mines or placers. What the Indians described as gold proved to be copper. Abundance of wrecks on the Atlantic coast of Florida during the sixteenth century, and great amount of treasure secured from them by the Indians. The character of the alloys in different specimens of metal now found resembling that of the product of the Spanish main confirms the views now entertained. The gold finds in Florida are very few; in most cases associated with objects of other metals or material only procurable from wrecks, or with such admixture of alloy as ensured their fabrication second-hand from the product of the Spanish main. Inference that all the known objects of gold found in Florida could only have come from that source.

A PORTRAIT PIPE FROM CENTRAL AMERICA. By A. E. DOUGLASS, American Museum of Natural History, New York, N. Y.

[ABSTRACT.]

APPARENT rarity of pipes, with bowls set angularly upon the stem, in Mexico at the time of the Spanish Conquest. Testimony of early historians and explorers as to the prevailing modes of smoking in Mexico and Central

[1] Printed in Popular Science Monthly for December, 1889.

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America. Tubes only of perishable material generally referred to. Tubes of stone used on the California coast. Pipes however with bowls, presumably of that period, met with occasionally in collections of Mexican relics. These are of terra cotta, frequently highly glazed and ornamented with incised lines.

Description of a pipe in a black slate, with three faces carved upon the bowl, found at a depth of twenty feet in debris of ancient Indian workings in a pre-Columbian gold mine in San Salvador, Central America. The faces there presented identical with those of early Indian tribes of that region not yet extinct. Attestation of the discoverer of this pipe to the circumstances under which it was found, which warrants the writer in considering it a veritable pre-Columbian relic of great ethnographical interest.

PREHISTORIC JASPER ORNAMENTS FROM MISSISSIPPI. By Prof. R. B. FULTON, University of Mississippi.

[ABSTRACT.]

A BRIEF account is given of the ornaments of this material which have been found in Mississippi at various times, with statements regarding their peculiarities and the difficulties in their manufacture, and reasons for supposing the work to have been done by one lapidary. A set of perforated jasper beads is shown, the total length of all the perforations being twenty-eight inches. Specimens of wrought quartzite of various structure and colors from southwestern Mississippi are shown, illustrating the materials found in the gravel beds of western Mississippi and utilized by the aborigines.

NOTES ON ABORIGINAL FIRE-MAKING. By WALTER HOUGH, U. S. National Museum, Washington, D. C.

[ABSTRACT.]

Two sticks are the tools of the aboriginal fire-maker. Wherever the lower races of men have been observed making fire they have, except in very few instances, been found to use this simple process of twirling one stick upon another.

There is a widespread belief among scientific men that this way is difficult. An extensive collection of the descriptions and personal testimony of travellers who have seen it done, shows that in almost all cases fire was easily and quickly made. Gauged by the observer's ability to repeat the experiment, it seems very hard; so it is when judged by the time and work

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taken by some tribes — who seem to have to some extent forgotten the knack.

Reducing this inference to a practical test the writer has repeatedly made fire on the wooden apparatus, quickly and with ease. With the simplest form, two sticks, he has made fire in twenty seconds; with the bow drill in less than five seconds.

Aside from the knack required we must have dry, combustible wood of the right kind; that which is semi-decayed is best. The friction of the wood grinds off a small heap of charred dust, in which the fire rises when the heat generated reaches 450,° or more.

Inferences:

1. Since fire-making by gyration on wood is easy, and almost universal among inferior races, there is a strong probability that it is the primitive discovery (invention).

2. The *culte de feu* and other instances of careful fire preservation are not caused by the "almost impossibility of making fire" of some authors, but is perhaps based on some feature of social economy.

The fire-making apparatus of the Indians and Eskimo were exhibited, and fire was made with the several kinds.

ABORIGINAL MONUMENTS OF NORTH DAKOTA. By Prof. HENRY MONTGOMERY, Ph.B., Grand Forks, Dakota.

[ABSTRACT.]

ON the morning of the 10th of July, 1883, I began my explorations of the aboriginal mounds of the Territory of Dakota, by opening the largest mound of a large group situated near the source of Forest river in Walsh county. Since that time I have excavated and explored thirty-nine ancient artificial mounds throughout North Dakota. Besides these, I have examined specimens obtained from at least ten others, and I have personally inspected the exterior of forty-eight more mounds in the same region. The mounds explored were in Walsh, Ramsey, Benson and Grand Forks counties. They may be divided into 1, BURIAL MOUNDS; 2, SACRIFICIAL MOUNDS; 3, BEACON MOUNDS. Only one Beacon mound occurred among them. There was one well-marked sacrificial mound, and another not so well-marked. The remaining thirty-six were burial mounds.

1. BURIAL MOUNDS. *Structure, situation and contents.* Of the mounds of sepulture there are two or more kinds, descriptions of which are here given.

(*a*) The ordinary burial mound, external views of which may be seen in figures[1] 1, 2 and 3, consists of a circular, rounded or conical heap of earth, mostly rich, black soil from the prairie, clothed with grass and rising generally to a height of several feet above the surrounding land. The height

[1] The illustrations here defined were shown at the meeting, but are not reproduced in this abstract.

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ranges from a few inches to twelve feet, and the diameter from thirty to ninety feet. In each burial mound, one or more vaults or graves occur, in which human skeletons and various implements, ornaments, trinkets, etc., are found. If but one vault or grave occur, it is nearly always in or about the centre of the mound. If two or more vaults occur, they are eccentric in situation, and from a few inches to several feet distant from one another. The vault is circular; in only one instance, have I seen it to vary from the circular or cylindrical, well-like pit, and in this case it was merely a little irregular. I have never found the vault to be rectangular or square. The vault is a well-like excavation in the ground, having a calcareous bottom and wall, and often also a calcareous covering consisting of a whitish-yellow layer two or three inches in thickness. The bottom of the vault is overspread with bark of some tree, and the vault contains on its bottom nearly a foot of pulverized yellow clay, which is surmounted by rich, black soil, similar to that constituting the general soil of the region. A vault ranges from three feet to seven feet and five inches in diameter, the average being about four feet. Its depth ranges from two to four feet. Its bottom is often six or eight feet below the top of the tumulus, and in one case more than twelve feet. For many years past, in my work of excavation, I have proceeded in this way:—I begin to dig and remove the sod and dirt from the top of the mound to a depth of one foot, and over an area fifteen feet in diameter, with the centre of the mound for its centre. Then another layer or thickness of like size is removed, and the depth is increased, foot by foot, always keeping a level floor in order that the location of the vault or vaults may be more readily determined. Wood is found from one to two feet down. This wood consists of poles or young trees, varying in diameter from three to ten inches. They were charred on their ends, and over the greater portion of their surfaces. When the yellow subsoil is reached, the loose dirt is carefully scraped off, and the vault may be at once perceived as a circular spot of soft, black soil, surrounded by a hard, yellowish-white clay. This is shown in figures 4 and 5, which are views of a mound on R. 65, T. 153, Sec. 12, Ramsey County, North Dakota. These were taken immediately after the vault had been located by the writer. Then I proceeded to remove the dry, loose, powdered, black dirt, and soon came to the yellow clay containing a human skeleton, one earthenware urn, one shell scoop, a birch-bark basket, a turtle shell, and several shells of large, fresh-water Unios. Here, as in all other instances where they occurred, the urn, basket and spoon were with the skeleton of a female.

The skeleton is generally found in a crouching posture, with back against the wall and face towards the centre, the ossa innominata upon the tarsal bones, and the shoulder, head and hands upon the knees. The other relics are found beneath or near the skull and breast.

Up to the present time, Aug. 10, 1889, I have explored twenty-four vaults, twenty-two of which were of the character just described, and the remaining two were slightly different. These twenty-four vaults were contained within twenty mounds.

(*b*) The second kind of burial mound differs chiefly in having no wood

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and no burial-chambers, and in the bones being greatly broken and greatly scattered. I have explored six of this class.

(c) There is, perhaps, a third kind of burial mound in this district. But, as yet, I have been unable to make a separate class for it. It would appear to be rather a variety of the second kind, than to form a distinct kind by itself. Its chief distinguishing characteristic is the possession of a layer of yellow clay two inches thick, which extends through the greater part of the mound and seems to overlie many human skeletons. It may possibly correspond to the covering of the vault or to the vault itself described in the first class. In this kind, however, no real vault or excavation occurs, and the layer of yellow clay is found two or three feet above the original surface of the ground. For convenience' sake it may be temporarily placed between the two preceding classes, until other mounds of similar character shall have been carefully studied. I have explored ten mounds of this kind.

The burial mounds, like all the others, are situated upon high ridges and hills, composed often of drift clays and boulders, and sometimes of gravel and sands. The position of more than thirty in Walsh county, is shown on the accompanying plans. [The location, dimensions, structure and contents of each burial mound were given in detail, and many specimens and photographic views of the crania, the vessels of pottery, the copper, stone, shell, bone and other articles taken from these mounds by the writer, were exhibited.]

2. SACRIFICIAL MOUNDS. The only really well-defined sacrificial mound which has been excavated and explored by me in this region, occurred on the south side of Devil's Lake, between Fort Totten and Sully's Hill. It was operated upon, September, 1887, and exhibited the following dimensions, characters and contents. [Here the particulars were enumerated.]

Another mound, somewhat resembling the foregoing, was opened near Sweet Water Lake in July, 1889.

3. BEACON MOUNDS. The beacon mound explored by the writer was situated in Benson county, and near Sully's Hill. It was operated upon in September, 1887, and exhibited the following dimensions, characters and contents. [Here the details were given.]

THE WINNIPEG MOUND REGION: BEING THE MOST NORTHERLY DISTRICT WHERE MOUNDS HAVE BEEN EXAMINED ON THE AMERICAN CONTINENT. By GEORGE BRYCE, LL D., Manitoba College, Winnipeg, Manitoba.

[ABSTRACT.]

THE Winnipeg mound region, examined by the writer, includes a district some four hundred miles from east to west, and running from the International boundary line northward, the furthest north mounds seen (but by another observer) being in about 52 N. latitude. The waters of this great

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region run into Lake Winnipeg, and the writer has here seen some sixty mounds, of which he has opened ten. The greater part of the work of excavation has been done in connection with the Manitoba Historical and Scientific Society. The mounds observed have been chiefly on the Rainy, Red, and Souris rivers. Numerous skeletons have been exhumed, and a skull from the mounds is before the Association, seemingly brachycephalic.

(1). Unmanufactured articles found:

Large quantities of charcoal, red and yellow ochre, and birch bark charred.

(2). Manufactured articles:

(*a*) *Stone implements* are numerous; *e. g*, knives, gouges, chisels, axes, mauls, conjuror's tubes, and a set of gaming stones.

(*b*) *Bones:* Breast ornaments of various types, bone whistles, beads, etc.

(*c*) *Shells:* Columella of conch from tropics. Tropical Natica and Marginella shells made into beads, wampum and breast ornaments.

(*d*) *Horn:* Fish spear.

(*e*) *Pottery:* Numerous fragments of marked pottery; one complete cup from Rainy river mound.

(*f*) *Copper:* Copper implements, all of native copper, which on examination by the microscope prove to contain silver, and are so identified with Lake Superior native copper. Circlet of native copper around skull in a Souris river mound.

(*g*) *Miscellaneous:* Near one skeleton, two lumps of arsenical iron pyrites, no doubt used as sacred objects; fragment of Baculite and a good sized Inoceramus in a Souris river mound, no doubt valued for their rich, nacreous covering.

Summary:

1. All mounds of this region are circular or oval.

2. Mounds are all on prominent headlands or ridges, hence for *observation*.

3. Majority of mounds contain skeletons, hence for *sepulture*.

4. Half-breeds of Red river say mounds belonged to the Mandrills, no doubt corrupted for Mandans, to whom extinct mound builders seem to have been related.

5. There is a persistent tradition among all the Indians, that the mound builders perished from small pox. This probably results from confusion of the facts that the mound builders were related to the Mandans, and that the Mandans of the Missouri some fifty years ago were almost exterminated by small-pox.

6. All mounds in this district are found in agricultural areas, showing mound builders to have been tillers of the soil.

7. Mound builders were probably Toltecans.

8. These mound builders, probably disappeared at the time of the destruction of the Hochelagans, Eries, Neutrals, etc., being crushed out between Sioux and Iroquois from the south, and the Ojibways and Crees from the north, say three hundred years ago.

9. Certain mounds from state of the bones, and from certain topographical and geological considerations, it is likely date the beginning of their central parts to four hundred years before that date.

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STEATITE ORNAMENTS FROM THE SUSQUEHANNA RIVER. By ATREUS WANNER, York, Pa.

[ABSTRACT.]

THE writer exhibited some steatite ornaments consisting of the following: disk, bead, perforated pieces of steatite dishes and several other ornaments, one of which rudely represented a human face.

From a close inspection of the various articles, the conclusion was drawn that the disks were made out of fragments of steatite dishes, and that probably the other ornaments were constructed out of steatite obtained from the same source.

THE "MIDE'WIWIN" OR GRAND MEDICINE SOCIETY OF THE OJIBWA INDIANS. By W. J. HOFFMAN, M.D., Bureau of Ethnology, Washington, D. C.

[ABSTRACT.]

THE so-called secret societies of the Ojibwa Indians have already been mentioned by Schoolcraft and other writers. One of the most important of them is the Midē'wiwin or Grand Medicine Society. In this is preserved the most interesting collection of myths pertaining to the Ojibwa cosmogony; the migration of the Anish'inâbēg, their ancestors; the origin and constitution of the society; the ritual of initiation and the secrets of prophecy. Mnemonic charts, pertaining to the above, have been collected and explained by the chief Mide' of the society.

Instead of being limited to a single degree, being all hitherto disclosed, this body is graded into four distinct degrees with the collateral branch—the Ghost Society — through which candidates may, under special circumstances, obtain the privileges of the first degree.

The writer has for two years been engaged upon official ethnologic investigations among the Ojibwa, and has secured very full and complete notes of the entire proceedings of this society, in consequence of which he this year resumes and hopes to conclude his researches, visiting the Ojibwa of the Upper Lakes, with the promise of being fully initiated into all the degrees and will add to his present notes the results of his initiation during the present summer to form part of the paper offered.

THE MISSIONS AND MISSION INDIANS OF CALIFORNIA. By HENRY W. HENSHAW, Bureau of Ethnology, Washington, D. C.

[ABSTRACT].

THE paper treated of the mission establishments, the purpose they were intended to subserve, briefly described the natives and their aboriginal mode

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of life. It described the methods of obtaining neophytes, the manner of converting them to Christianity, the discipline administered; also the labor required of them and their instruction. It finally discussed the causes of the failure of the missions and the marked decrease of Indian population.

A map was exhibited showing the location of the missions and the number and distribution of the linguistic families to which the mission Indians belonged.

SIOUAN TERMS FOR "MYSTERIOUS" AND "SERPENT." By Rev. J. OWEN DORSEY, Takoma Park, D. C.

[ABSTRACT.]

THE attention of the writer having been called to the article on "Serpent Symbolism" in the Iroquoian languages by Mr. J. N. B. Hewitt, published in the American Anthropologist for April, 1889, a similar investigation of the Siouan terms was made, the results of which are now presented. This article will be published in the American Anthropologist.

The following languages and dialects are compared: Dakota (Santee, Yankton and Teton dialects), Dhegiha (Omaha and Ponka, Kansa, Osage and Kwapa), Tci-we-re (*i. e.*, Iowa, Oto and Missouri) and Ho-tcañ-gara or Winnebago.

The term "Wa-ka^n" (or some derivative) is found in all these languages, but it varies in meaning. By a reference to the author's paper on "The Comparative Phonology of Four Siouan Languages," read at the Montreal meeting of 1882 and published in full in the Smithsonian Report for 1883, it will be seen that the Winnebago is probably the most ancient of the four languages. In that as well as in the Tci-we-re, *serpent* is still called wa-ka^n. The other languages have different words for *serpent*, but the Dakota has retained wa-ka^n as meaning *mysterious*, though that language seems to have changed more than the Dhegiha and Tci-we-re.

"GENS" AND "SUB-GENS AS EXPRESSED IN FOUR SIOUAN LANGUAGES. By Rev. J. OWEN DORSEY, Takoma Park, D. C.

[ABSTRACT.]

IN the American Anthropologist for April, 1888, appeared an article entitled, "Meaning of the Words for Gens in the Iroquoian and Algonquian Tongues," by J. N. B. Hewitt, of the Bureau of Ethnology. In it Mr. Hewitt stated that in nearly all the Iroquoian languages the word for gens

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also signified clay or mud, and that he had found a like similarity in the Algonquian. This is not the case in the four Siouan languages under consideration.

The Dakota *gens* is called o-ce′-ti (o-che′-ti), literally, *fire-place;* hence, the national name O-che′-ti sha′-ko-win, *Seven Fire-places*, comprising the seven original gentes, now tribes, Mdewakantonwan, Wakhpekute, Wakhpetonwan, Sisitonwan, Ihanktonwan, Ihanktonwanna and Titonwan. Among these, the *sub-gens* is known as the ti o-shpa-ye, *a group of those who camp by themselves, apart from the main body.*

The Omaha and Ponka call the gens ta^{n}′-wa^{n}-gdha^{n} u-ba′-na^{n}, or ta^{n}′-wa^{n}-gdha^{n} u-ba′-te, *a village* or *group of people springing from a common stock.* By the way, ba-na^{n}′ and ba-te′ refer to *a clump of trees springing from a common root* or *stump. All the gentes*, taken as a whole, are described as ta^{n}′-wa^{n}-gdha^{n} ba-na^{n}′-na^{n}, or ta^{n}′-wa^{n}-gdha^{n} ba-te′-te. The *sub-gens* is called either ta^{n}′-wa^{n}-gdha^{n} u-ki′-gdha-sne [*a segment of a village*, or *one of the parts into which a stump has been split* (u-ga′-sne)], or u-ne′-dhe, *a fire-place.* The Kansa have the term, ta^{n}′-ma^{n} u-ki′-pa-te, sociative in form and therefore applicable to the *sub-gens* rather than to the gens.

The Osage tell of their three grand divisions, the Tsi′-cu u-tse pe-dhŭ^{n}′-pa (*Seven Tsishu Fire-places*), the Haⁿ′-ka u-tse′ pe-dhŭ^{n}′-pa (*Seven Hanga Fire-places*), and the Wa-ca′-ce u-tse′ pe-dhŭ^{n}′-pa (*Seven Osage Fire-places*), all twenty-one gentes being in the Osage nation or confederation. The writer has gained the names of sixty-seven gentes and sub-gentes of the Osage, but not the term for sub-gens.

The Tci were tribes (Iowa, Oto and Missouri) use the term ki-kra′-tce for *gens*, as Wa-ka^{n}′ ki-kra′-tce, *They call themselves* (after a) *Serpent, i. e., the Serpent* or *Snake gens.* Their name for *sub-gens* was not obtained though each Iowa gens had four sub-gentes, whose names (excepting those of one gens) have been recorded, and there are still four sub-gentes in one Missouri gens.

The Winnebago name for *gens* is i-ki′-ka-ra′-tca-da, answering to the Tciwere ki-kra-tce. Hence, Ta′ i-ki′-ka-ra′-tca-da, *They call themselves* (after a) *Deer*, or *the Deer gens.* No name for *sub-gens* has yet been found by the writer, though there are sub-gentes in the Bird gens.

[To be printed in the American Anthropologist.]

INDIAN PERSONAL NAMES. By Rev. J. OWEN DORSEY, of Takoma Park, D. C.

[ABSTRACT.]

AT the Ann Arbor meeting of this Association in 1885, the writer read a paper on the subject of Indian personal names (published in full in the Proceedings for that year). A letter from Professor Chamberlain of To-

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ronto induced the writer to undertake the preparation of an extensive monograph on the same subject, to be published by the Bureau of Ethnology. There will be six lists, in which the Indian names will precede their English meanings: Winnebago, 380 names; Iowa, Oto and Missouri, 506; Kwapa, 15; Osage, 470; Kansa, 593; Omaha and Ponka, 1182. These will be followed by a general list of the 3146 names, in which the English meanings will precede the Indian originals. Several examples are given. Reference is made to the connection between the myths and some of the personal names. Certain classes of names are treated in detail, among which are color names, iron names, whirlwind names, thunder-bird names and the names of composite beings. One of the last, Moon Hawk Female, reminds the student of an Egyptian hieroglyphic. Genealogical tables of gentes of two tribes are referred to in the paper and will be given in full in the monograph.

ONOMATOPES, INTERJECTIONS AND PHONETIC TYPES. By Rev. J. OWEN DORSEY, Takoma Park, D. C.

[ABSTRACT.]

THIS paper treats of the sound-roots (onomatopes), interjections and phonetic types of the Omaha and Ponka dialect of the Dhe-gi-ha, a language of the Siouan family. Whenever possible, the writer has given the Indian notation of the sound associated with the onomatope. While many roots now denote the effects of certain acts, it is very probable that some of them originally referred to the sounds made in producing those effects. Examples are given. An English writer of the last century collected a number of examples in his own language, to show that a certain collocation of consonants at the beginning of a word generally designates the class of ideas intended to be conveyed by it. Thus, *st*, idea of *rest*, *stability*, as in stand, stay, stop, stick, still, stall, stool, etc. (also idea of *motion*, as shown in words given by Horne Tooke); *sl*, idea of sliding, etc., as in slip, slide, slime, slippery, etc. Compare words in *gl*, glance, glide, etc. The writer claims that similar phonetic types exist in the Dhe-gi-ha and cognate languages.

PLACES OF GENTES IN SIOUAN CAMPING CIRCLES. By Rev. J. OWEN DORSEY, Takoma Park, D. C.

[ABSTRACT.]

IN the camping circles of the various Siouan tribes there is no uniform order of gentes. When we compare the customs of the several tribes, we are led to ask several questions: 1. Have not certain gentes shifted their

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camping areas? 2. Has there been any consolidation of gentes or subgentes? 3. Has there been segregation or differentiation of gentes or subgentes? 4. Are there instances of emigration from one tribe to another of a common stock? 5. Has a new gens been formed by the adoption of foreigners (*i. e.*, those of another linguistic stock) into the tribe? The writer undertakes to answer these questions in the paper, treating first of the Dakota tribes, then of the Dhe-gi-ha, Tci-we-re and Ho-tcañ-ga-ra.

[This paper has appeared in full in the American Anthropologist for October, 1889].

THE GESTURE LANGUAGE OF THE BLACKFOOT INDIANS. By Rev. Dr. JOHN MCLEAN, Moosejaw, N. W. T., Canada.

[ABSTRACT.]

DIFFERENT gestures of the Northwest Indians.
Gestures relating to tribes.
Names of tribes designated by gestures.
Gestures descriptive of some characteristic of the tribe.
Mode of reckoning by gestures.
Gestures relating to measurement of time.
Gestures relating to counting.
Hunting and war gestures.
Signalling.
Miscellaneous gestures.

ONONDAGA SHAMANIC MASKS AND THEIR USE. By DECOST SMITH, Skaneateles, N. Y.

[ABSTRACT.]

EARLY notices. Bartram (John), 1743. Morgan (Lewis H.), 1852. Turtle shell rattles used in connection with masks. Cited and figured by Lafitau, 1724. Description of masks. Masks symbolical of supernatural evil beings, called Hon-do'-I. Their aid invoked to drive away witches. They cause or remove illness. Are propitiated with feasts and sacrifices of Indian tobacco. Description of these ceremonies. Exhibition of masks and rattles.

THE IROQUOIS WHITE DOG FEAST. By Rev. WM. M. BEAUCHAMP, Baldwinsville, N. Y.

[ABSTRACT.]

DOGS were much used in Indian feasts, especially those of a warlike or religious nature. The Mohawks sometimes sacrificed bears instead of men, and may have had a periodical feast. That of the white dog, among the

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Iroquois, seems to have combined the early war and dream feast in a newer custom, of which our earliest account is in the latter part of the last century. It was a festival of the new year, and we have various accounts of it. Besides the early descriptions of the feast at its proper time, we have mention of the sacrifice in Sullivan's campaign in the autumn of 1779.

In its rites the False Faces have a prominent share, and there is an atonement for sins, a purification of houses, and often a relighting of fires. Dances occur throughout, the Onondaga feast lasting fourteen days, and the Seneca a shorter time. The Senecas kill the dog or dogs several days before the burning; among the Onondagas the strangling and burning are on the same day. Some other differences appear. Among the ceremonies are the confession of sins, naming of children, adoption of desirable persons, and a kind of prophetic gaming. The original Indian tobacco only is used at this time. The feast has greatly changed, and will soon entirely disappear.

INDIAN BURIAL IN NEW YORK. By Rev. WM. M. BEAUCHAMP, Baldwinsville, N. Y.

[ABSTRACT.]

BURIAL customs vary greatly in New York. The sitting posture was quite frequent, but in most known cases facing the east. The horizontal posture was less common, but quite as old. In both cases articles may or may not be found with skeletons. Small houses or casements were sometimes made over graves; in others there might be a low mound, often resulting in a depression. True burial mounds and ossuaries are occasional, but mostly in western and northern New York. Early graves were lined with bark; later ones with plank. Stone graves are quite rare. Several instances of radiating burial are known, mostly recent. Burial by clans is yet practised among the Onondagas, but with innovations. Reversed burial, the head downward, was rare, and may have been a punishment. Among the Onondagas witches were cast into rocky crevices, and stones were heaped over them. In the Mohawk valley several headless skeletons were found in graves on which bowlders had been cast. Stone heaps sometimes occur over graves, but these had other uses. Burial in tiers is found by Cayuga lake. Allusions to the gathering of bones and placing them under the roots of trees are found in speeches, but the Nanticokes alone are clearly described as taking up and reinterring their dead.

ALGONKIN ONOMATOLOGY, WITH SOME COMPARISONS WITH BASQUE. By ALEX. F. CHAMBERLAIN, Toronto, Ont.

[ABSTRACT.]

THE subject of comparative onomatology is of importance as an evidence of the mental acquirements of the races of people compared. It is

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closely related to history and folk-lore, as both these sciences are called into play in the interpretation of names (here taken in the widest sense). Comparative onomatology, as far as regards our Indian languages, is almost an unexplored field. There are several groups which afford an inviting harvest, such as the Siouan, Iroquoian, Algonkin, with their numerous dialects. It is with Algonkin, however, that the writer of this paper intends to deal, turning to the Basque at times for useful illustrations and comparisons. The subject may be divided under several heads, viz.: (1) Names of inanimate objects of nature, earth, sea, sky, sun, moon, stars; as moon, in Cree, *tipiskâwipisim*, in Ojebway *tibigisiss*= night sun; Basque *illargi* (moon)=light of death. (2) Names of animals, birds, insects, fish, etc.: gopher, in Cree, *potatchikasew*, in Ojebway, *potatchipingwasi* = the thing that blows up loose earth; crawfish, in Cree, *asâkew*, in Ojebway, *ashagashi* = the thing that moves backward; whitefish, *attikamek* (Cree), *atikameg* (Ojebway)=the caribou-fish (the caribou of the waters); swan, in Cree, *wâpisiw*, Ojebway *wabisi* = the white (bird); in Basque, *saguzara* (bat)=old mouse; weasel, *angereder*= pretty maid; dory (fish), *arraingorri* = red fish. (3) Names of trees, plants, fruits, etc.: sassafras, *menagwakomis* (Mississagua)=scented tree; oak, in Cree, *maskwâttik*= hard wood; a sort of willow, *mahiganâttik* (Cree)=wolf's wood; cranberry, *maskekomin* (Cree), *mashkigemin* (Ojebway)=*muskegamin* (Mississagua)=marsh-fruit; strawberry, *otchemin* (Cree), *otémin* (Mississagua) *odéimin* (Ojebway)=heart-fruit; in Basque, oak, *aritz*=the hard (stony) wood; quince *ira-sagar*, ira-apple; osier, *zume*=thin, small tree. (4) Names of implements, instruments, etc.: Bead, *manitominis* (Mississagua)=mystery-seed; chisel, *eshkon* (Mississagua)=horn; needle, in Cree *sâbonigan*, Ojebway *shabonigon*=that which pierces; in Basque, sling, *uballarri*=stone-thong; axe *aizkora*, connected with *aitz*=stone. (5) Names of seasons, months, etc.: January, in Cree, *kisipisim*=the great month, in Ojebway, *manito-gisis* = spirit-moon; May, in Cree, *niski-pisim* = month of the outarde, in Ojebway, *wâbigoni-gisis*=moon of flowers; compare in Basque: *urtarrilla* (January)=month of waters, or perhaps month of the year = principal month (?), *ostoilla*, *ostaro* (May)=month of leaves, time of foliage. (6) Names of members of the human body, etc.: thumb, in Cree, *misitchichân*, Ojebway, *mitchitchinindj*=great finger, in Basque, *beatzlodi*, *atzlodi*, (thumb)=thick finger. (7) Names of animals, plants, instruments, materials, objects, etc., of exotic origin: Horse, in Cree, *mistatim*=big dog, in Ojebway, *papajicogishi*=the animal with undivided hoof; sheep, in Ojebway, *manitanis*, in Cree, *mestjanis*=the animal with the hide that is not durable; carrot, in Ojebway, *osawtchies*=yellow turnip; looking-glass, in Mississagua, *wabimotchichagwan*=where ghosts are seen; shot in Mississagua, *shishibanwing*=duck-stones. (8) Ethnic names, *Nehiyawok* (Crees) =the true, real, men; *Mississagwé*=those who dwell where there are many mouths of rivers; *Potawatomi*=fire-makers (let. we are making fire); according to Long the Ojebway call themselves *Neenawesik*=they who speak a natural language; compare the Basque *euskara*=the Basque language, *euskaldun*=a Basque (*euskara*, according to Humboldt=the language par excellence). (9) Personal names: *Ogimabinesh*=chief-bird, *Asawbanung*

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=stars in a cluster, names of Mississaguas at Scugog; in Basque, *Echeberri* =new house, *Echegaray*=excellent house. (10) Words of onomatopœic origin: in Cree, *wehwew* (goose), *ahâsiw* (crow), *kâkâkiw* (raven), *kokus* (hog), *sisib* (duck), in Ojebway, *wewe* (goose), *shishib* (duck), *kakaki* (raven), *kokosh* (hog). In Basque, *kakaraz*, clucking of hens, *irhinziri*= neighing of horses. (11) Words (apparently radical) of which the etymological significations are not apparent:

	(bear)	(bee)	(blueberry)	(earth)	(moose)	(porcupine)
Ojebway,	*nukwa*,	*amo*,	*min*,	*aki*,	*mo^{n}s*,	*kak*,
Cree,	*maskwa*,	*âmow*,	*min*,	*askiy*,	*monswa*,	*kâkwa*.

In Basque: toad *abo;* fish, *arrai;* head, *buru;* *ego*, wing; *gau* (night); *ibai*, river.

(12) Words denoting abstract ideas often of recent origin.

Many of the words to be considered involve questions of history (*e.g.*, the names given by the Algonkins to the English, French, Americans, etc.) or of folk-lore (*e. g.*, the names of the rainbow, milky way, etc., and some names of animals, etc., as the raccoon) and are of the greatest value in the study of the development of aboriginal ideas.

THE TWO BROTHERS: A MISSISSAGUA LEGEND. By A. F. CHAMBERLAIN, Toronto, Ont.

[ABSTRACT.]

THE writer related a legend dictated to him, both in Indian and English, by an aged Mississagua woman at Scugog Island. The tale, which is a very old one, is peculiar on account of the variety of incident and actions performed by the hero *Assemōka* (the tobacco-maker). Assemōka and his brother camped together long ago, and the former made up his mind to travel into the world. So at length he set out and after being metamorphosed into a tree, and a stick in the river (by his own volition), from which positions he is rescued by his brother, he travels (after the latter has declared he will help him no more) until he comes to a village in which all the people except a boy and a girl are dead. Assemōka finds out that they have been killed by a bad old woman who set them to fetch the white loon that dwells in the middle of the sea, a task they failed to accomplish. Assemōka obtains the white loon for the children and tells them to ask the old woman to get the chipmunk's horn; this she fails to do and Assemōka kills her. He then makes a little bow and arrows for the boy, and tells him to shoot up into the air three times which he does, and at the third time the people rise from the dead.

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The phonetic alphabet of the Winnebago Indians. By Miss Alice C. Fletcher, Peabody Museum, Cambridge, Mass.

In the winter of 1883–4, while I was with that part of the Winnebago tribe living in Nebraska, a party of Sauk and Fox Indians arrived to make a visit. They numbered fifteen or twenty and were in full Indian costume and bent upon enjoying old-time pleasures. I met these visitors several times; they came not infrequently to see me when I lay upon my sick bed. One of the men told me of a visit which he and some of his people had paid to the Chippawa Indians and how when they were there they had become interested in the revival of some old Indian customs and rituals which bore upon the moral training of men. He then at some length detailed to me maxims and instructions which were very like those given in certain ceremonies among the Iroquois and which were associated with the myths and legends of Hiawatha. My Indian informant had all the zeal of a new convert and talked long and earnestly with me concerning the religious beliefs which had come down from his ancestors, and he assured me that, were the pure codes of morality, such as he cited, enforced, the Indian would rise to be far superior in character to his white brother. The Chippawas, who had made so great an impression upon him, lived in northern Minnesota, but he could not tell me the English name of their band. He declared that there was a wave of religious revival passing over these Chippawas, and he was desirous of being an apostle of the new faith to the Winnebagos. As he talked and repeated the formulas of this reform movement, I was so much struck with their resemblance to the teaching among the Iroquois, that I asked him from whom the Chippawas had received these lessons? He replied: "They were taught by Indians living further to the East." Who these eastern Indians were my informant did not know. The interest of this Indian in the new religion, as he termed it, was well known to his companions, some of whom declared themselves to be its followers. There was talk of trying to interest the Winnebagos in the reform, but I think the attempt failed, although I know a few men who were approached. The demand for abstinence from all intoxicating liquors hardly suited modern taste.

I have never been able to follow up this interesting movement, or to learn more of these intertribal exchanges of native religious teachings in modern times. It was certainly suggestive as to how certain modifications and resemblances found in ceremonies of tribes living distant from each other, may have come about.

It was from these same Sauk and Fox Indians that I first heard of a phonetic alphabet existing among them and used by them to write their own language. The alphabet was spoken of as the invention of one of the tribe in recent years, but as none of the visitors could write it, I could not then obtain a copy. Within a year from the time of the departure of these guests, some Winnebagos went to visit the Sauk and Fox, and one of the Winnebagos while there acquired the alphabet and became an expert in

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its use. In August, 1885, the agent of the Winnebagos wrote me: "The tribe have suddenly taken to writing their own language, and people who have never learned English have acquired this art. The people claim they took the basis of it from the Sauk and elaborated it themselves. It is a very suggestive sight to see half a dozen fellows in a group with their heads together working out a letter in these new characters; it illustrates the surprising facility with which they acquire what they want to learn."

During my recent sojourn among the Winnebagos of Nebraska, I inquired concerning this new alphabet and was told it had been learned from the Sauk, but when they first knew of it or who invented it I was unable to learn. The Winnebago, who on his visit to the Sauk first learned the alphabet, soon discovered its adaptability to write Winnebago, and he so applied it. Upon his return to his tribe, he taught others the use of it and now the knowledge of it has spread over the Winnebagos of Nebraska and of Wisconsin, and the principal correspondence of the tribe now takes place in these characters. I have seen many of these epistles.

This phonetic alphabet consists of seventeen of our letters and two new characters, making nineteen symbols in all. Thirteen of the letters borrowed are consonants and four are vowels.

Of the thirteen consonants, six only retain their English sound; these are M, N, Th, W, Y and X.

The other seven are as follows, with their equivalent sounds:

B = pee.	D = jar.	G = gwar.
K = ga.	L = R.	R = S.
T = td.		

The four vowels, a, e, i, o, have the following sound: ä, e̲, ï, o. The capital A = hah.

The two new characters are: đ = sh; *m* = rk. These sounds can best be heard in combination with a vowel. [The German đ is here used to represent the first of these characters, but it is nearer to a Roman d crossed by a long comma. The italic *m* is here used to represent the second character, but this is more like a continuous wavy line.]

đa = shar. Kam = gark.

There is no spelling; the fifteen initial sounds with their four vowel modifiers form 128 combinations, like syllables, and with these one can easily write any words in the Winnebago language.

A few examples will show how this alphabet is used:

Wank shick ra,	means people;	the word is written, Wa k đim la.
She shick,	means bad;	the word is written, đi ctim.
nump,	means two;	the word is written, no ba.
Henuka,	the name of the eldest daughter;	written, Ai no k.
Sin ne hhee,	means cold;	the word is written, Ri ni Ai.

The syllables are spaced; the words are seldom run together in the writing. It sometimes takes a little ingenuity to read a letter, as the close of the word is not apt to be marked by a wider space than that used between the syllables.

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Duties have called me west of the Rocky mountains, where I am unable to trace the origin of this ingenious alphabet, which, so far as I know, has never before been presented to the public. I shall be grateful for any information concerning the use of this chart among other than the Winnebago and Saux and Fox tribes, and also concerning any similar methods in use among other tribes.

I have examined the Cherokee alphabet, thinking this one might be an outgrowth or corruption of that invented by Sequoah, but it does not seem probable to me.

The education of Indian youth in English has set Indians to thinking of how they can preserve their language, and I have seen many boys and some girls who have labored to make our English letters bend about the Indian words. It would seem as though we might in time expect several such inventions as this chart, but they will all probably have the same fate as our own childish devices to create a new language and a new alphabet.

There are many points of interest in this chart which will at once catch the eye of the students of languages, and I trust will be of some service to them and science. [See next page.]

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PHONETIC ALPHABET AS USED BY THE WINNEBAGO INDIANS.

Ka = gah	Ke = gay	Ki = gee	Ko = go	Kam = gark	Kem = gake	Kim = geek	Kom = goke
da = jah	de = jay	di = g	do = jo	dam = jark	dem = jake	dim = geek	dom = joke
wa = wä	we = we	wi = wi	wo = wo	wam = wärk	wem = werk	wim = week	wom = woke
xa = xä	xe = xe	xi = xi	xo = xo	xam = xärk	xem = xerk	xim = xeek	xom = xörk
ta = tdä	te = tde	ti = tdi	to = tdo	tam = tdärk	tem = tderk	tim = tdeek	tom = tdörk
ma = mä	me = me	mi = mi	mo = mo	mam = märk	mem = make	mim = meek	mom = moke
na = nä	ne = ne	ni = ni	no = no	nam = närk	nem = nake	nim = neek	nom = noke
La = Rä	Le = Ray	Li = Ree	Lo = Row	Lam = Rark	Lem = Rake	Lim = Reek	Lom = Roke
*ga = gwar	ge = Gway	gi = gwee	go = gwo	gam = Gwark	gem = Gwake	gim = Gweek	gom = Gwooke
*ra = Sah	re = say	ri = see	ro = So	ram = Sark	rem = Sake	rim = seek	rom = soke
Tha = Thä	The = They	Thi = The	Tho = Tho	Tham = Thark	Them = Thake	Thim = Theek	Thom = Thoke
Ya = yä	Ye = yea	Yi = Ye	Yo = Yo	Yam = Yark	Yem = Yake	Yim = Yeek	Yom = Yoke
ba = pah	be = pay	bi = pee	bo = po	bam = park	bem = pake	bim = peek	bom = poke
a = ä	e = e	i = i	o = o	am = ark	em = ake	im = eek	om = oke
ða = shar	ðe = shay	ði = shee	ðo = sho	ða = shark	ðem = shake	ðim = sheek	ðom = shoke
Aa = hah	Ae = hay	Ai = hee	Ao = ho	Aam = hark	Aem = hake	Aim = heek	Aom = hoke

In this table I have preserved the exact order as given me by my Winnebago friend. The order is certainly different from that in which one of my race would be apt to arrange this phonetic alphabet, but it may yield something toward discovering the secret of the origin of this curious arrangement, by revealing the manner in which sounds group themselves to the Indian ear.

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A FEW NOTES UPON THE ESKIMO OF CAPE PRINCE OF WALES, HUDSON'S STRAIT. By F. F. PAYNE, Meteorological Office, Toronto, Ont.

ONE of the chief troubles to contend with in making notes upon the customs of the Eskimo is their extreme sensitiveness to ridicule, and it is therefore most necessary that you should put on your gravest expression when questioning them. Sometimes this sensitiveness is very interesting to watch. Upon one occasion when employing my favorite Eskimo, Ugaluk, as an assistant in my boat and telling him to throw out the anchor he immediately picked it up and carrying it to the bow was in the act of casting it overboard without a rope attached to it. We were just in time to stop him and naturally laughed, rather immoderately, at which he sat down in the boat and covering his face with his hands remained in that position for a long time, and was too shy to speak to us.

If offended at any time with their own people, or either of my men, they would immediately leave and without saying a word would go home and for some time they were not to be seen. We sometimes regretted that they could not be offended oftener, for most of them required continual watching when anything movable was about.

One afternoon several men entered our house and standing near the fire refused most positively to go out. Knowing that promptness of action has a good effect upon them, one of them was immediately handled rather roughly and stumbling fell as he was bundled out of the door, the others following suit. For a minute we thought there was going to be trouble; the next moment, however, they picked themselves up and all turning with smiling faces said "chimo, chimo," which means we are friends. I may add that orders to leave our house after this were never disobeyed.

Whilst, as a rule, the Eskimo looks upon the white man as born to do him favors, those met with would sometimes offer payment for our services; and for the burial of an aged relative, who died when his friends were away hunting, one of my men received the valuable gift of about two gallons of blubber which of course he accepted with many thanks. Nevertheless if an Eskimo was given an unusually valuable present, he would immediately turn round and ask for the most impossible things as though he thought you were now in a good humor and now was the time to get all he could from you.

As far as could be seen it seemed to be the general belief that all property, especially in the way of food, belonged to everybody in common and therefore, if you held more than another it was only because you or your family were physically strong enough to protect it. Few men of course would steal from one another when food was plentiful, thereby making enemies for themselves, but, when food is scarce, might is right, and all make note of the position of their neighbors caches before the winter's snow covers them.

At one time after a raid had been made upon my storehouse by some rather desperate Eskimo, my trusted friend, Ugaluk, informed me that his wife had gone to get a share of the plunder. At first we were inclined to

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harangue him for infidelity but soon saw he had not the slightest idea it was wrong to receive stolen property. Upon another occasion, under similar circumstances, I induced Ugaluk to help me track the robbers and with some trouble we traced them to a deep gorge where all we could see was a large hole in the snow. This was the doorway of an igloo, ten feet below the surface, which had been covered by continuous drifting of the snow. Into this hole Ugaluk dived while I remained outside. He soon returned and asked me to follow, which I did upon my knees for some distance until I found myself in a very dirty dimly-lighted room. Sitting near the lamp was a woman and by her were three children, these being the only occupants of the place. The woman denied most emphatically any knowledge of the theft and was not moved in the least when informed that her husband would stand a chance of being shot if he took part in another burglary. Feeling that perhaps after all we were mistaken we were just leaving, when the woman called us back and holding up a small piece of salt beef said, this was all her husband had taken as unconcernedly as though she had never denied it and as though he had found it outside our door instead of having done a great deal of damage in securing it.

The Eskimo, of all races, are the most free and in no case do they consider a man their superior unless he or his family are physically stronger or are better hunters than others. These superior men are treated with little deference, though they are usually sought for in the settlement of disputes and sometimes act as public executioners. Ugaluk, who had all these qualities, was usually obeyed when an order was given by him, and we were much interested with his story of a comparatively recent execution which he undertook for the good of the community. Walking up to the offender he held him in conversation for a few minutes when suddenly drawing a knife from his sleeve he plunged it into his breast and then finished him upon the ground, afterwards carrying his body out upon his kyak and dropping it into the sea. As Ugaluk related his story in a whisper he trembled violently and it was quite evident he was haunted with certain fears.

As in civilized communities there were several restless individuals living among those we met who at different times had dwelt in many parts of the coast, one of whom at least had lived far up Fox Channel. These individuals are employed as traders and evidently are the means of keeping the language intact.

As is well known, work is pretty well divided among these people, the men doing all the hunting and making and repairing implements, while the women take part in everything else, even in the making of boats and building houses, though the more laborious part of this work is performed by the men.

When moving to a distant part of the coast a small pack is put upon each dog, and the men and women divide equally the heavy goods to be carried. When the snow is soft the dogs are shod with seal skin shoes.

The Eskimo's powers of endurance are wonderful. During the winter

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of 1885–86 many of those about me were reduced to mere skeletons through starvation, and although they were helped as much as possible, several, it is to be feared, died not far from us. Some had eaten the skin covering of their bed and were only saved by an occasional seal being killed and by the few lemmings they could catch under the snow. In one instance a case of what appeared to be economic hibernating was noted. Some distance from the Observatory a woman and her son were found closely huddled together in a house completely closed and not much larger than themselves. They said they had not had any food for some time, but expected friends in a few days. Leaving what food we had we returned to the station, and extremely bad weather coming on some days afterwards, we had almost forgotten these people. Two weeks later we were reminded of them by an Eskimo having passed that way who said he had not seen them. Fearing they were dead we went over with provisions and much to our surprise found them, though little more than parcels of bones, perfectly well, and they declared they had lain there ever since. These people with others were soon stout and hearty when food became more plentiful.

In many of the narrow gravelly passes in the rocky hills, low walls were often noticed that had undoubtedly been built many years ago. These were in a straight line from one hill to another and were usually nothing more than single stones about a foot high placed close to each other. Many conjectures as to their use were made and taking Ugaluk to one of these walls one day he informed me that many years ago when large numbers of Eskimo lived here and wood was extremely scarce some would bind sharp stones to their feet and lying upon their backs behind these walls others would drive the deer, which were then very numerous, and as the deer passed over the walls the hidden hunters would strike with their stone-tipped feet and would often kill many of them in this way. Regarding the scarcity of wood it may be added that even now many Eskimo have not harpoons because they cannot procure a piece of wood large enough for a handle.

Having often heard of the dislike the Eskimo is believed to have to a white man exploring the graves of their dead, we determined to test this and purposely went with several Eskimo, passing near where a number were buried. Here I stopped at one grave which had evidently long ago been visited by wolves or dogs, for the covering of stones had been dragged away and the bones were scattered in every direction. To my surprise the Eskimo looked on quite unconcernedly as I turned the skull and bones over with my stick, and, if anything, they seemed rather amused than otherwise. Suddenly I feigned an expression of fear, and while they looked at me made a bound forward, screaming as I fled. In a moment they were after me screaming apparently in greatest terror. Soon stopping, however, I burst into laughter and was immediately followed by all excepting the children who evidently could not see the joke, nor would they return to the grave. During the remainder of my stay here we often examined other graves, but from a warm attachment for the dead, as well as for the living, not a bone was ever removed.

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SHINTO: THE RELIGION OF THE JAPANESE. By ROMYN HITCHCOCK, Washington, D. C.

[ABSTRACT.]

THE paper read is itself an abstract of a longer article in which the mythologic system of the Japanese is considered more fully, and the influence of the beliefs of the people upon the national character discussed.

The system begins with three deities formed spontaneously in space, after which come two creator gods, who, by natural processes, give birth to the islands composing Japan and afterwards to a host of deities to govern it. Some very interesting myths are related, the significance of which is not very clear and finally the succession of generations concludes with the birth of the first Mikado who is a descendant of the sun, or of the goddess Amaterasu, the deity of the sun.

The native chronology runs back to 660 B. C., and the mythologic lore purports to go back for about 10,000 years more. But no dates in Japanese history can be relied upon earlier than 400 A. D., when the historic era may be said to begin.

The subject cannot be satisfactorily presented in a short abstract, as the conceptions of deities and their conduct are peculiarly Japanese and require to be understood from a Japanese and not from an Aryan standpoint.

THE ANCIENT PIT-DWELLERS OF YEZO. By ROMYN HITCHCOCK, Washington, D. C.

[ABSTRACT.]

THROUGHOUT the Island of Yezo and extending north into Saghalin and through the chain of islands, extending northeast, known as the Kuriles, peculiar excavations in the ground are found. These were first observed by Mr. Blakiston, about 1872, but have since been noticed by others. In the course of a long journey in Yezo, during the summer of 1888, the author observed many of these pits and made efforts to obtain remains of pottery, shells, etc., from pits near Nemuro, and on the Island of Yeterof, but without success.

The pits are supposed to be the remains of dwellings which, according to Aino tradition, and perhaps also to certain references in Japanese literature which may bear the same interpretation, were occupied by the predecessors of the present inhabitants of Yezo.

The only known representatives of people inhabiting dwellings of the kind are a small colony on the island of Shikotan, originally from the Kuriles. This colony was visited by the author and the dwellings were carefully examined.

A Japanese writer has also described dwellings built over pits in Saghalin, but not much dependence can be placed upon his descriptions, as he did not enter the houses.

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ANCIENT JAPANESE TOMBS AND BURIAL MOUNDS. By ROMYN HITCHCOCK, Washington, D. C.

[ABSTRACT.]

THE most ancient form of burial in Japan was in a simple mound of earth, perhaps in a wooden coffin. Cave burial was also practised, the caves being hewn out of solid rock, and the dead placed in stone or earthen coffins. After this came mounds of two forms, one with stone chambers with long entrance passages, constructed by piling up large stones and covering them with earth, the other large double mounds surrounded by one or two moats.

The latter are quite common in Yamato province, where many of the early emperors are buried in such tombs. Their form is like a long mound, of perhaps one hundred feet in height, running north and south, with a slight depression near the middle and constricted at the sides. The south end is square, the north end rounded in plan. Interment was near the top of the north end.

The sides are terraced and the soil kept in position by concentric rows of clay cylinders, about two feet in length by eight inches or a foot in diameter.

In early times, it was a custom to bury the persons in attendance upon a high officer upright around his grave. As they were buried alive up to the neck, they suffered greatly until relieved by death. One of the early emperors desired to stop this custom and called his councillors together that they might devise a plan for suppressing it. One of them advised that clay figures should be made to represent men and horses, and that these should be buried instead of living persons. The suggestion met with favor, and now very strange figures are occasionally, though rarely, found about the tombs which were buried instead of human sacrifices.

THE DOKHMAS OR PARSEE TOWERS OF SILENCE. BY MRS. ROMYN HITCHCOCK, Washington, D. C.

[ABSTRACT.]

AN account of the Parsee Dokhmas at Bombay, with notices of the origin of the custom of exposing the dead to be eaten by beasts and vultures. The Parsees were expelled from Persia by the persecutions of the Mohammedans, and finally established themselves in Bombay, where they now number about 72,000, constituting an influential and wealthy portion of the community. They retain their old customs and observances. The paper was illustrated by original photographs and drawings.

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ON THE EVOLUTION OF ORNAMENT — AN AMERICAN LESSON. By W. H. HOLMES, U. S. Bureau of Ethnology, Washington, D. C.

[ABSTRACT.]

THE evolution of ornament is a topic of interest to all men. American art furnishes a large body of data bearing upon this subject which deserves very careful consideration. This is especially true since the primitive character of our aboriginal art renders its use in the study of questions of evolution comparatively easy. It is intended in this paper to dwell only upon the development of certain well-known conventional designs. Two arts, the textile and ceramic, are found to be almost exclusively concerned. Elements of decoration enter these two arts in two great currents one of which carries mechanical and the other graphic elements. When once within the realm of decoration these elements are subject to the action of two great forces, the æsthetic desires of the mind, and the technical or mechanical agencies of the art.

The two leading questions that arise are, 1st, how do the mechanical elements inherent in the arts develop into certain definite highly constituted forms, and 2nd, what part do nature derived elements take in the same work?

It appears that, granting the moving force to be the æsthetic desires of men, the formative agencies pertain to the art, its material processes, etc., and are for the most part technical in nature. In the textile art these agencies are very pronounced and it is easily shown that through their action all forms, mechanical and graphic, tend to assume the linear geometric character. Arts of more or less graphic or plastic nature act in their own ways to produce corresponding results.

It is seen that strong resistance to the tendency of the arts to reduce all graphic forms to the purely geometric is offered by the association of ideas with the delineations. We have here the conservative force of art, which in order to express ideas clearly holds tenaciously to the first form of expression, the graphic.

CONTENTS OF CHILDREN'S MINDS. By HARLAN H. BALLARD, President of the Agassiz Association, Pittsfield, Mass.

[ABSTRACT.]

1. GERMAN students have tested children by carefully prepared series of questions designed to disclose: *a*, their processes of thought; *b*, the amount of their knowledge.

2. Result of putting the questions used by the German philosophers, in examining German children of seven years, to my own son, aged five years, nine months and eleven days. His exact replies.

3. Additional questions designed to test his powers and habits of independent observation, memory and general information, with his replies.

4. Illustrations of reasoning ability in a child of five.

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SEEGA, AN EGYPTIAN GAME. By DR. H. CARRINGTON BOLTON, New York, N. Y.

[ABSTRACT.]

THE author learned the game of Seega from Bedouins in the Desert of Sinai. It is similiar to draughts yet has novel principles and is a clever game of skill. The author illustrated his paper by a blackboard diagram.

THE AFRICAN IN CANADA. By JAMES CLELAND HAMILTON, LL.B., Toronto, Ont., Can.

[ABSTRACT.]

THE introduction referred to the various races found in Canada, but of all these, whether native or immigrant, it was claimed that when the history of the last fifty years is written, none will be found more interesting, as a class and as parcel of the state, than the colored population.

Under this head were included all having African blood, pure or mixed, in their veins.

In Canada the black refugee was surrounded by an active white population, had seldom any capital but his strong right arm, and had to lay his plans so as to rival the white man and "take his bread out of the stump." It was shown that no such contest had, in any other place before American Emancipation, been undertaken by the African race.

The speaker stated as his object, to present such an account of the course of this people as from observation and documents, but especially from personal enquiry, he had been able to gather during a residence of some thirty years in Toronto.

At the beginning of this period, in 1860, there were about 40,000 colored people in Upper Canada, few being found in the other provinces.

Reference was then made to proceedings at conventions of people of color, in the United States, so far back as 1831, in which the prospects of the west coast of Africa and the West Indies as places for their immigration were discussed, but these were overruled in favor of Canada West. At this time several thousands of fugitives from slavery had settled in our province. The Rev. Isaac J. Rice from Ohio and Rev. Hiram Wilson came to work among them and were aided by Quakers and other philanthropic Americans. After them the Rev. William King followed bringing from Louisiana his slaves, fifteen in number, whom he freed and settled in the township of Raleigh on Lake Erie near the town of Chatham. An Association styled in honor of the then governor of Canada, the "Elgin settlement" was formed August 10, 1850. A tract of land containing nine thousand acres of good soil was procured. The place was called Buxton, in honor of Sir T. F. Buxton, and here began the work of colonizing and making homes for the fugitives on an extensive scale. The land was leased and finally sold only to colored people and on such easy terms of payment

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as made it practicable for them to purchase. Mr. King himself lived for twenty-five years in the settlement as agent of the Association, missionary and teacher, and has had the satisfaction of seeing the land all sold, cleared and occupied by his people. He has, in late years, lived in Chatham, but seems satisfied with the success of his self-denying efforts and in a communication to the essayist stated "the Elgin settlement has accomplished what we intended, which was to show by a practical demonstration that the colored man when placed in favorable circumstances was able and willing to support himself, and although the soil and climate were not the same as those which they left, yet these people have done as well as any white settlement in the province under the like circumstances." Some of the young men educated at Buxton have been elected to civic offices in the United States. One was James Rapier, a member of Congress from Montgomery, Alabama, during General Grant's administration. "Others are," says Mr. King, "teachers, preachers, doctors and lawyers." "Most of the educated colored people," he also states, "left Canada during the war and very few are coming to it now."[1] The writer then gave instances of *Slaves* and *Slave Law* in Canada and an account of Solicitor General Gray and the Baker family as follows:—

"The propriety of importing African slaves as an economic measure was considered in the Council of Quebec as early as 1688 when the Attorney General visited Paris and urged upon the King the expediency of importing negroes as a remedy for the scarcity and dearness of labor. The King consented but advised caution owing to the severity of the climate. A few slaves were brought in but the system never flourished." (Parkman's Old Regime in Canada, p. 388.)

Slaves were made also of Pawnee Indian captives, but their dislike of steady employment and propensity to escape to the woods impaired their value, says the same authority.

Court records show traces of both negro and Pawnee slavery in the Lower province till February 18, 1800, when the court of King's Bench at Montreal discharged the negro *Robin* from custody, and this decision being acquiesced in, practically ended the system there. This and the accident of climate saved Quebec from future servile trouble. The province now called Ontario was but sparsely inhabited. Slavery did exist to a limited extent in Upper Canada, till 1793, when an act was passed by the infant parliament of that Province, at the town of Newark, now Niagara, prohibiting the importing of slaves, and declaring that no negro or other person brought into Upper Canada should be thenceforth subject to the condition of a slave.

It will be noticed that in this our Province had the honor to precede the mother country, which passed the act emancipating slaves in all her colonies in 1833. It is but fair to note that Pennsylvania and Rhode Island

[1] In 1863, Messrs. R. D. Owen, James McKay and S. G. Howe, members of the "American Freedmen's Commission," visited Buxton, made careful inquiry and reported as to the condition of the colored people there. Their report helped to add the 14th amendment to the U. S. Constitution.

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had shown us an example, emancipation having been decreed in those states in 1780. Ours was a rare little Parliament that so honored itself, sitting sometimes in its chamber at Navy Hall and then as the day grew sultry, adjourning to the shade of a spreading tree, as Dr. Scadding describes the scene. There were but a baker's dozen of them in all, seven crown appointed councilors and five commoners. Mr. McDonell of Glengary was the speaker.

The act then passed also made provision for the gradual emancipation of the three or four hundred slaves then in the Province. Down to the year 1833, when the imperial act referred to took effect, some of these old slaves were still to be seen in Canada, even as such were to be found within very recent years round the old homesteads of New Jersey.

Dr. Scadding has collected in "Toronto of Old" several references to slavery in this province as practised early in this century; among those offering to deal in the human article being the governor, Peter Russell, who in 1806 advertised for sale a black woman Peggy, and her son Jupiter.

Slave advertisements were then common in the Quebec Gazette. In the western part of this province the great Indian Chief Brant, or Thyendenaga, had African slaves, it is said, but I have been unable to verify this historically. He was a contemporary of Governor Russell. Our Indians were too nomadic to make African slavery profitable with them. It was, in fact, of most rare occurrence in the northern tribes, while in the south blacks tilled the soil of Cherokee and Choctaw farmers.

The amiable characteristics, forming the pleasant part of the history of slavery on this continent, were so exhibited, in the life of the late Solicitor General of Upper Canada, Mr. Robert Isaac Dey Gray, that I am tempted to give some details of his career not generally known.

He was son of Colonel James Gray, who was a Highland Scotchman of good family. Mr. Gray lived on the north side of Wellington Street in Toronto, then Little York. As part of his family he had a colored slave woman Dorin, or Dorinda, Baker and her children, among them her sons John and Simon. A sad fate awaited him and Simon his gay young body servant. A court was ordered for trial of an Indian murderer, at Presque Isle in county of Northumberland, then Newcastle district. This being before the use of steam, Judge Cochrane, the Solicitor General and his servant, with the sheriff, embarked on the government schooner 'Speedy,' Captain Paxton, for the place of venue. A gale came on, all went down and were lost on the night of 7th October, 1804. By his will, made August 27, 1803, Mr. Gray "manumits and discharges from the state of slavery in which she is now his faithful black woman servant Dorinda" and gives her and all her children their freedom. To John and Simon he also left two hundred acres of land, and directed that twelve hundred pounds should be set apart and the interest applied to the maintenance of the family.

I am indebted to Judge Pringle of Cornwall, Ont., a relative of the Gray family, for the extract of a letter written by Mr. Gray to his cousin Catherine Valentine at Kingston, Feb. 16, 1804. After giving an account of his

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endeavors to recover property abandoned by his father, who had been a major in the first Battalion, King's Royal regiment of New York, he states "I saw some of our old friends while in the States; none was I more happy to meet than Lavine, Dorin's mother. She was living in a tavern with a woman by the name of Bromley. I immediately employed a friend to negotiate for the purchase of her. He did so stating that I wished to buy her freedom, in consequence of which the man readily complied with my wish and, although he declared she was worth to him £100, he gave her to me for $50. When I saw her, she was overjoyed and appeared as happy as any person could be, at the idea of seeing her child Dorin, and her children once more, with whom if Dorin wishes she will willingly spend the remainder of her days. I could not avoid doing this act. The opportunity had been thrown in my way by Providence and I could not resist it. I saw old Cato, Lavine's father, at Newark, while I was at Colonel Ogden's. He is living with Mrs. Governeur, is well taken care of and, blind, poor old fellow, came to *feel* me for he could not see me. He asked affectionately after the family."

John Baker survived the others of his mother's family and died in Cornwall, 1871, at a patriarchal age. For the last nine years of his life he had a pension from the English government for services in the war of 1812. On August 11, 1868, I met John Baker and got the story of his life, which is redolent of old times and customs and is that of one of the last Canadians born in bond service. I give it as he told it. First let me picture him as a very dark mulatto of amiable disposition and countenance, hobbling from rheumatism and laying down his wood-saw as I asked him to sit down on a box in a grocery, and handed him a plug of his favorite weed. "I was born at Quebec, brought up at Gray's Creek. My mother Dorinda, was from Guinea, my father was a Dutchman, probably a Hessian soldier. Old Colonel Gray, father of 'Solisary Gray,' was colonel of a Scotch regiment and wore kilts and married in the United States. I came to Gray's Creek near Cornwall, when a boy, and Gray's son was then also a lad. I lived here with Mr. Farrand who used to go on horseback and had his trunk strapped on my back. He rode like a Tartar, and the trunk used to knock on my back. Young Gray was the only child of the Colonel and went to Parliament thirteen years running. The Colonel was strict and sharp and put deerskin shirts and jackets on me, and gave me a good many whippings. Simon was older than me, and was 'Solisary' Gray's body servant. I lived two years in Toronto, or Little York, in a large white house, north of the boat landing. The people was proud and grand them days. Simon was dressed finer than his master with a beaver hat and gold watch. Governor Hunter ordered the party to go to the trial in the 'Speedy.' He was a severe old man and wore leather breeches. In one pocket he carried tobacco, in the other snuff and when giving his orders he would take a handful of snuff, and it would fall over his fine ruffled shirt,—fine, I tell you, no mistake, and silver buckles to his shoes. Never saw him with a boot on. Solisary Gray when he went off last, told me to look after the place and he would be back in a day or two. They started between four and five in the evening

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and we heard of the loss next morning from the brig 'Toronto.' There were in York about twenty houses then.

"After that I went to Judge Powell's. A recruiting agent came along, and I listed. Judge Powell paid the smart for me seven times. I said, 'thank you, sir,' and I listed again. I served three years in New Brunswick. Col. Drummond was then colonel and Col. Moody was lieutenant colonel. Moodie who was shot on Yonge street and Drummond scaling ladders at Fort Erie. I was at Waterloo in the 104th Regiment under Col. Halkett. We chased Napoleon, who rode hard and jumped the ditches. We marched over our shoes in blood. I saw Wellington, General Brock and many other great men in my time. We came back to Canada and got our discharge. I was a wild, foolish boy. The Lord will be with us all by and by, I hope. Good-bye."

Mr. Hamilton next discussed the cause celèbre of John Anderson the fugitive slave, arrested in Toronto under the Ashburton Treaty in April, 1860, for killing one Diggs in Missouri, when escaping. He was released by the court of common pleas on a technicality, after much legal argument and public discussion and excitement.

Professor Aytoun's story of Haman S. Walker, as related in "Blackwood," thirty years ago, and again in the novel "Norman Sinclair," was referred to. Walker is represented as a villain who, pretending to be a suffering abolitionist, came to Toronto, ingratiated himself with the colored people, married the daughter of a well-known livery-stable keeper, took her south, secured a bill of sale of her father, from his former master, sold his wife, and when the father came to Charleston to redeem his daughter, he found himself the chattel of his worthy son-in-law, and had, as is represented, to redeem both. This witty tale the essayist declared he had found to be entirely untrue. The professor was the victim of a cruel hoax. The young woman referred to married a colored man and removed to Milwaukee.

A résumé of two interesting discussions in the Canadian parliament, having reference to imposing a capitation tax on colored immigrants, was then given. Mr. Larwell was mover in the lower house, and Col. Prince in the other. Both motions were negatived. During one of these an amusing incident occurred. The gas went out. A member rose and solemnly said, "Mr. Speaker, I move that light be given on this dark subject." An account was given of instances of loyalty of this race to their adopted land, and of their refusal to accept inducements to go to Hayti, Trinidad and elsewhere. Some personal references were then made to the colored people in Toronto, Hamilton and elsewhere in the province. The Nestor of Toronto is John Tinsley who came from Richmond, Va., and claims to have completed his one hundred and sixth year on last fourth of July. He is a quadroon; his father Captain Samuel Tinsley served in the Revolutionary and Georgia Indian wars. He is an interesting old man, and has a store of knowledge of Old Virginia days.

The history of Josiah Henson, commonly known as the original "Uncle Tom," was given. He was a man of much natural ability, gathered his people around him at Dresden, Ont., went to England and New England,

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and lectured to great audiences who, as did Lord Shaftsbury, Earl Russell, Archbishop Tait and others, aided him in his enterprise. The Queen asked him, "Have you any family?" "I have ten children, forty-four grandchildren and nine great grandchildren, your majesty," I answered. "Why," she exclaimed, "you are a patriarch." The archbishop asked him, "At what university, sir, did you graduate?" "I graduated, your grace, at the university of adversity." "The university of adversity," said he, looking up in astonishment, "where is that?" I saw his surprise and explained my meaning.

The English papers made him famous as "Uncle Tom." Interesting reminiscences of the life and labors of this remarkable man were then given. He was born a slave in Charles county, Virginia, June 15, 1789, and died in Dresden, Ontario, on May 5, 1883. As a result of his labors mainly, the Wilberforce Institute for the education of colored youth was founded at Chatham, where it is still doing good work. The writer closed as follows:—It has been variously estimated that of our colored citizens those of pure blood were between one-fourth and one-third of the whole number, the others being mulattoes or of the other mixed classes. About half of the adults were fugitives from the south, and these were esteemed by Mr. King as the best class, as they possessed that activity and manliness by which they secured freedom. Besides a difference in the shades of color we should also remember that the negroes found in Canada are descendants of various African tribes, some of which were intelligent, vigorous, and full of martial spirit, while others were of a lower calibre, some even signifying with a few almost inarticulate expressions, in their native wilds, all the desires which their rude life called for, or gave rise to. Some of those originating from the former African stock are esteemed equal in natural intelligence to whites of like station and opportunities, while the latter could not be raised by any educational process to the same level.

From this diversity of origin probably arise, to a great extent, contradictory opinions regarding the capacities of the race. Some who draw their conclusions from their experience among the inferior, judge that all the tribes, and their American descendants, are equally degraded while others are as much led astray in an opposite direction, by regarding only the superior classes.

The part of Ontario occupied by these people is rich in soil and has a climate similar to that of Michigan, yet the general opinion I found current, both among themselves and others conversant with the subject, is that it is not the country best adapted to their natural requirements. They are specially liable to phthisical diseases. I should remark, however, that doctors disagree on this point, and I speak with diffidence but think the weight of authority will be found as just expressed. There are many persons of advanced age among them. Many of the colored men, who were found in our gaols, were not of the class of fugitive emigrants proper, but of the criminal ranks, who evaded the penalty of crimes committed in the states by escaping across the border. The statistics from penitentiaries

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and prisons; especially during the period before emancipation, must be regarded with proper allowance for these circumstances. A friend, who has been for many years a county crown attorney, and has had much experience of this people, condensed his views thus:—"There was a reaction after the enforced labor of slavery. The black folks regarded with suspicion any effort to guide them politically or morally. They were not thrifty and did not lay up much for the future, as a rule; but improved in this, as they learned necessity from experience. They were easily led astray by designing men, among whom were many cunning half-white fellows. The offences with which they were charged were generally the result of weakness, rather than vicious disposition, 'minor crimes, seldom felonies."

The wonderful changes in the political and social aspect of the land, whence they fled, again pointed these people to that as the land of promise for them and their children. As a summary of their views before these changes, and irrespective of them, allow me in conclusion to read a short extract from a resolution passed at a colored convention held in Toronto in September, 1851.

"We feel grateful as a people to her Britannic Majesty's just and powerful government for the protection afforded us, and we are fully persuaded, from the known fertility of the soil and salubrity of climate of the milder regions of Canada West that this is by far the most desirable place of resort for the colored population to be found on the American continent.'"

I have now given an imperfect, but I trust, an accurate view of the career of this race in Canada. I claim for our Dominion, but especially for this Ontario province, that she has in her schools and colleges, in her legislatures and in her courts, in heart and in hand, been the good Samaritan to the sons of Ham in their days of trouble. But it is not in any spirit of boasting, however moderate or patriotic, that I would close this account of our colored fellow citizens and their career in Canada.

This race must have a great future on this continent, though it is expected that as Africa is opened up, many will return to the land of their forefathers. The Indians become Metes, but the black man becomes blacker, more distinct and more African. He daily grows in numbers, in knowledge and in power. The Canadian problem has worked out happily. We have had no Pharaoh to distress our land of Goshen nor have plagues disturbed us. The former involuntary exodus to the north has been succeeded by a voluntary interchange of people and products over the bridge of peace and freedom which unites our countries.

The greater problem looms before you. We do not fear the result, if knowledge and science do their part.

Whatever be our political future, we of the north must share, and bear, with you of the south, one grave united interest, in the working out of this great racial problem in the social destiny of the continent. We say in the words of the pious Æneas:—

"Una salus ambobus erit."

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ARTIFICIAL LANGUAGES. By Prof. DAVID R. KEYS, University College, Toronto, Ont.

[ABSTRACT.]

THE scientific value of an artificial language consists not merely in its usefulness to investigators but in the light that the adoption of such a language would throw upon the old question as to whether language exists as a natural growth or as a convention.

An historical sketch of the attempts to create an artificial language, with special reference to the early efforts of Leibnitz and Wilkins. The merits and defects of modern inventions such as those of Schleyer (Volapük) and Esperanto, of which the latter would be preferable on account of its simpler grammar and more practical character.

Finally a doubt was expressed whether it was not better that the scientific worker should study two or three modern languages as the best training in the comparative method which is the basis of all modern research.

RESULTS OF EXPLORATIONS OF AND ABOUT THE SERPENT MOUND OF ADAMS CO., OHIO (In aid of which a grant was made by the Association). By Prof. F. W. PUTNAM, Peabody Museum, Cambridge, Mass. [To be printed in full in the Century Magazine, April, 1890.]

DISCOVERY OF A NEW LINGUISTIC FAMILY IN CALIFORNIA. By H. W. HENSHAW, Bureau of Ethnology, Washington, D. C.

GOVERNMENT OF THE SIX NATIONS. By O-JI-JA-TEK-HA, Toronto, Ont.

THE HURON IROQUOIS OF THE ST. LAWRENCE AND THE LAKE REGION. By Sir DANIEL WILSON, Toronto, Ont.

THE ACCADS. THE EARLIEST BABYLONIANS. WHAT WAS THEIR DESCENT? WHAT GREAT MODERN NATION IS DERIVED FROM THEM? By Miss VIRGINIA K. BOWERS, Newport, Ky.

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SECTION I.

ECONOMIC SCIENCE AND STATISTICS.

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ADDRESS

BY

CHARLES S. HILL,

VICE PRESIDENT, SECTION I.

ECONOMIC AND SOCIOLOGIC RELATIONS OF THE CANADIAN STATES AND THE UNITED STATES, PROSPECTIVELY CONSIDERED.

"What God hath joined together" — no man can rend asunder.

JOINED by natural conditions of creation, by ties of consanguinity and language, by bans of matrimony and posterity, these two peoples, assembled here to-day, of the Canadian States and the United States, must eventually be one and inseparable — inevitably.

Our relations with the Canadian people are closer than our relations with those of any of our sister American Republics, although of similar form of government, because of the difference in the language of the latter.

The science of God in nature is far grander than the science of man in art.

In His infinite wisdom our topographic conditions are one and inseparable.

By His divine will our language of communication is one and the same, and the Christian cross is our religious emblem of one faith, whether of the Anglican, Roman or Grecian branch of the church.

These are the unifying elements which render our destiny one as a people and one in government.

These conditions are *de facto* and unchangeable, therefore they need no consideration.

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Our economic and sociologic relations are problematic, and an analysis of the prospective conditions thereof can but be of benefit and interest in anticipation of union or not, but the union of these two peoples in one government eventually is as certain as the union of territory is now definite and unalterable.

Two committees of the United States Congress are already in the field studying this problem from a political point of view, and that a lively and important discussion will take place at the coming session of Congress in Washington next winter is very certain.

Grave and serious may be the immediate results of the coming consideration as an international question, in view of the remarkable existing and rapidly developing conditions that are assuming such complicated features, but the ultimate result will be annexation and consolidation.

In view of the existing conditions on the one hand and the prospective conditions on the other, there seems to be no more pertinent and important an economic problem for consideration before this Section to-day.

I shall not pretend to analyze each specific subject of these conditions in cause and result, but merely open a discussion as to the economic measures and sociologic benefits to be attained in the future; nor shall I burden you with statistical data more than in a few tabulations, for such are familiar to you all.

The many distinguished economists of scientific study and world-renowned fame attending this convention, and who have recorded special papers to be presented to you during our sessions, will more ably interest and inform you.

When we compare our natural conditions with those of the many peoples of the Old World, what a mighty contrast is presented, and what a volume of thought is suggested.

On this new continent the English tongue has sounded over lakes, reëchoed over the plains, and reverberated over seven millions square miles, from ocean to ocean, obliterating the dialect of hundreds of thousands of immigrants yearly and silencing in extermination the tongues of the aborigines.

On the old continent we find different peoples and hear different tongues within the short distance of every few hundred thousand square miles. From the Hebrides of Europe to the Himalayas of Asia, to the far north of Siberia, we listen to a confusion of languages, find a variety of religions and religious superstitions, and we see that even rivers, as well as

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"Mountains, interposed, make enemies of nations
That else, like kindred drops, have mingled into one."

With us a continent is being developed into homogeneity by the inspiring and subduing force of the English language, and what is being done on this continent is also being done the world over, and by the same cause—the unification of the English-speaking people.

OUR ECONOMIC RELATIONS.

Of the United States, what can be said?

Endowed with wonderful and unexampled prosperity that have blessed us for a century of years, through great vicissitudes of political circumstances, in peace and in war; in the possession of a soil that has yielded far more than ample harvest for our wants of every character; in the knowledge of owning vast undeveloped mineral resources of untold and inestimable wealth; under an established economic policy of government laid down by our fathers, who framed our Constitution and who enjoined upon us to follow their policy, and which has only twice been interrupted by indiscreet and ruinous political passion in legislation—it appears natural that our neighbors and friends of the Dominion of Canada should be blessed with like possession of riches in geological, agricultural, and industrial development, at present denied them by legislative limitation and requirements, not necessary to dwell upon here.

It seems to us, blest with such past and prospective prosperity, singular that you of Canada should not be unanimously anxious to become united to such a people and form of government.

And of Canada, what?

The etymologic significance of the Indian *Kannatha* is no longer applicable to the Dominion of these great Provinces; *La Nouvelle France* has long since lost its significance, if not its identity.

Relatively in resources the present Canada is as wonderfully wealthy, as rich in fertility of soil, and as progressive in enterprise and genius as is the United States. During the last decade the Dominion has made more rapid strides in the utilization of her possessions and opportunities than ever before.

The vast area of the Dominion offers a supply of several natural products in greater abundance than the United States, and even some which we do not possess.

With a climate varied but little from our own, except in the most

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northern part, there appears in the near future a grand prospect for immense settlement and great prosperity.

But the historic phrase of *British* North America is even now a misnomer and will soon become obsolete.

There are "*Three Americas*"— North, Central and South. Of the first, from the Arctic to the Gulf there can be but one people eventually, of one language and of one government.

The similitude of Republican government between the United States and Central America is a tie of strong sympathy, but language and consanguinity bind us closer to you of Canada.

It has been truly said that the ties of blood were stronger than water, but it may be added that ties of language, religion and blood must, sooner or later, blend us, now two peoples, into one.

UNIVERSAL CONDITIONS.

Let us then consider the conditions and prospects that we find before us.

A commercial union is impracticable, for there must first be universality in political government, as well as in economic and sociologic conditions and national assimilation.

It would be preposterous to establish a free-trade policy with Canada and preserve a protection policy with England. The side-door entrance would be used exclusively for commercial intercourse with Great Britain and the trade of our Atlantic and Pacific seaport cities would be ruined and the prosperity that our merchants have enjoyed would be known no more forever. The employment which they now distribute to the poorer classes of those thickly-settled and thriving cities would be not only interrupted, but destroyed. Loss of wages, idleness, discontent and strife, would result as surely as such a basis of intercourse should be established with a people that belonged to and were under the government of a European nation. Were you of Canada an independent people a commercial union would be a very different matter for consideration.

But as long as the Canadian people are under the control of the British government, which now rules the seas and the commerce of the world, to open such a side door of traffic would be cutting the artery of our industry and bleeding of our workmen to death.

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A commercial union with Canada would, of course, be practically a commercial union or a free-trade traffic with Great Britain.

As well might we establish the union direct and better that we declare free trade to the world.

Assimilation of political interests must come before a "commercial union" is possible.

How shall it come? The United States cannot court it or tender a protectorate to the Dominion. It would be directly contrary to our national policy to acquire territory by means of aggression.

Canada must be the suitor. She must make her peace with her home government and obtain the consent of mother England before entering into a matrimonial alliance with ourselves. Whether the United States must assume the debt of Canada or pay a consideration in money will be a question of agreement.

GOVERNMENT.

Autocracy, plutocracy, democracy, which?

For one hundred years the people of Canada have failed to become assimilated even in themselves.

For one hundred years the people of the United States have been banded as one, except during the brief period of political passion—in which the flames and fury of prejudice were fanned by influences from abroad — and by ignorance of true politico-economic principles at home; but the dark cloud of strife and difference has passed, and now, more purified in love and stronger in reason for the sad lesson learned, we are *one*, "now and forever."

Why, then, this great contrast in similitude of conditions existing between two people, side by side?

It is because of the difference in form of government.

Ex-President White, of Cornell University says that—

> "The first requisite to a good government is to educate the great mass of citizens to the point of grasping simple political questions,"

and so it is emphatically.

Between autocracy and democracy there seems to have sprung up a fear of plutocracy, or rule of wealth, in our remarkably prosperous country, but that fear can be calmed by the reflection that in the country where the poor man has an equal chance with the rich man—provided that industry and integrity are equally prominent—plutocracy is impossible.

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The Premier of Canada, Sir John Macdonald, is, of course, in his earnest loyalty to England, a zealous monarchist, and has no taste for the agitation about the question of annexation of his people to ours, for he well knows that it could only be done by renouncing the autocracy of the royal family and assuming the democracy of our people.

It is to his wisdom and foresight, however, that Canada owes her progressiveness and advancement in the last ten years; but it would be only fatality that caused him to realize that his skilful statesmanship and economic judgment only hastened the accomplishment of annexation to our people's government—the last result that he desired.

Perhaps the most witty observation upon this subject has come from the Hon. Mr. Chapleau, Canadian Secretary of State, at a dinner in Montreal recently, viz.: that, while he did not wish to disparage the United States he would say that if they were to annex themselves to Canada it would be good for them. But he erred very much in the prospective view when he added that "these movements towards the United States mean only one thing—destruction to Canadian industries," for such has not been the experience of any state or territory of our Union.

Mr. Erastus Wiman, who is well informed concerning the interests and circumstances governing both peoples, says he regarded it as

"Unfortunate that the whole continent was not included in the American Revolution. Only Great Britain's liberal policy, which she exercises toward her vast western colony, and which she learned to be imperative for peace one hundred years ago, has made possible the continued colonial existence of Canada. The Dominion is to-day intensely loyal to the English government, because of the extended influence of the Orangemen, who resist the encroachments alike of Americanism and Catholicism; because of the six hundred and fifty millions of dollars of British capital invested in Canadian enterprises; because of the influx of British emigration, which deliberately chooses British land in which to live and because of the undesirable character of the exiles who seek in Canada immunity from punishment for crime committed in the United States."

To take a view from another side, which is the only just means of learning the true sentiment of a people, let us listen to the expression of the Premier of the province of Quebec, the Hon. Honoré Mercier, who says that "*Quebec is a British colony only in name.*"

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He adds—

"The aspirations and ideals of her people are as un-British as they well can be, and their hearts beat for France and not for Britain. It is not the record of Saxon achievements that stirs their pulses.

"With two races that have spilled each other's blood on half a hundred fields from the days of Agincourt down to Waterloo, Canadian statesmen are trying to build up a nation, and after more than a century of intermingling the materials are found to be as incongruous and as unmixable as they were on the day when the *fleur-de-lys* bowed its splendors before the valor of Wolfe under the walls of Quebec. Who will say that the task is not a colossal one? It begins to look as if it were a hopeless one."

Premier Mercier presents the point of consideration forcibly for reflection upon the contrast between the people of Canada and of the United States:

"How comes it, Americans may ask, that Canada has failed to assimilate the French Canadians, when the states have assimilated and made American citizens of the people of every clime on the globe?"

Here is strikingly impressed the influence upon the spirit of the people under an autocratic in distinction from those under a democratic form of government.

UNRESTRICTED TRADE.

Do reciprocity treaties reciprocate?

This question requires careful consideration and reflection, much more than it is possible to present to you in an address this evening, and certainly much more than seems to be given by the major part of political representatives of either nation.

Reciprocity treaties are generally economic and sociologic, and are termed "*Commercial and Amity Treaties.*"

The former comes under this division of my argument because it is a contribution to or deduction from the public revenue of a people and should be framed by a practical body of economists and business men, not by politicians. The latter comes under the following division because it is a diplomatic tie governing the sociologic conditions of one nation with another, and may be, perhaps, more happily drafted by the genial warm-hearted, and theoretical diplomatist than by the cold, hard-headed, calculating, and money-making merchant.

Reciprocal treaties are good enough so far as they protect against

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discriminations of trade tricks in the ports of two countries, but for growing countries like the United States and Canada to be circumscribed and handicapped by bodies of diplomatic obligation against economic interests and development is absurd. For instance, we find ourselves, by our infantile treaty of 1818 with England, which we have outgrown, ridiculously appearing as an overgrown man wearing the short clothes of boyhood, mortified and smarting yearly under the obligation to our parent country, which is now infinitely the smaller, to the disparagement of our commercial interests of the breaking of good faith.

To show this absurdity authoritatively, however, and the danger of short-sighted, so-called reciprocity treaties, I quote from a report of the Committee on Commerce of the United States House of Representatives, May 28, 1842, made through its chairman, Hon. John P. Kennedy, of Maryland, a statesman and economist. That Report, No. 835, 27th Congress, 2d session, page 27, says:

"The aim of our Government has been to establish reciprocity in trade.

* * * * *

"It seems to have been imagined that reciprocity consisted in equal privileges of importation and exportation in our own vessels and the vessels of the nation with which we established these relations; that the greater the scope given to these privileges of import and export, the nearer the approach to perfect reciprocity."

This Committee of Congress did not make a superficial research into the cause of civil results in our commercial conditions, but thoroughly cut to the germ of the disease by analytical dissection, as will be seen by reference to that remarkable document:

"Our commerce has been proffered to the world upon terms dictated by the most friendly disposition, and with a sincere desire to give the utmost scope to the expansion of commercial adventure." * * *

"Our citizens have acquiesced for years in these arrangements, under the specious delusion that, as the system professed to be one of *reciprocal* advantage, we have gained by it reciprocal freedom of trade."

The Report adds with severe comment:

"The Committee have already pointed out the *fruits* of this reciprocity."

It is of interest here to examine the record of our treaties so as to place correctly in the mind the character and date of each that we have made with nations professedly reciprocating the benefits anticipated and to judge of the results.

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TREATIES, OBSOLETE AND EXISTING.

The first commercial treaty of our country ever made was with France, in 1778, but it was afterward broken by that country in its principles of amity and economic relations, which caused an interruption of our navigation and commerce upon the Atlantic Ocean.

The order and date of these treaties under the old Government were, viz.:

Old Confederation.

1778, Feb. 6	France	Amity and commerce.
1782, Oct. 8	Netherlands	Amity and commerce.
1782, Oct. 8	Netherlands	Recaptured vessels.
1783, Jan. 20	Great Britain	Armistice.
1783, Apr. 3	Sweden	Amity and commerce.
1783, Sept. 3	Great Britain	Peace.
1785, July 9, 28; Aug. 5, Sept. 10	Prussia	Amity and commerce.
1788, Nov. 14	France	Consular.

These were all the treaties of the original Government, made from the date of rebellion against British Commercial Taxation to the reorganization under the title of United States of America, March 4, 1789.

Under the reorganized Government our first treaty with Great Britain was of Peace, Amity, and Commerce, dated November 19, 1794. It was the first treaty under the Constitution of the United States, and signed by "Grenville" and John Jay, to which was afterward appended an additional and an explanatory article signed by "Bond" and Timothy Pickering. This treaty, however, although fully detailed specifically, was not in force long, but supplemented, as will be here shown, by sharp diplomacy to the disadvantage of our people from the year 1815 to the present day.

The schedule of existing commercial treaties is as follows:

Reciprocal Commercial Treaties of the United States existing at present (alphabetically arranged).

Nation.	Date of Treaty.	Nation.	Date of Treaty.
Argentine Confederation	July 27, 1853	Corea	June 4, 1883
Austria-Hungary	Aug. 27, 1829	Costa Rica	July 10, 1851
Belgium	Mar. 8, 1875	Denmark	April 26, 1826
Bolivia	May 13, 1858	Dominican Republic	Feb. 8, 1867
Brazil	Dec. 12, 1828	Equador	June 13, 1839
Chili	May 16, 1832	France	Sept. 30, 1800
China	Nov. 17, 1880	Germany	July 8, 1815

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Nation.	Date of Treaty.
Great Britain	July 3, 1815
Supplemented	Oct. 20, 1818
Renewed	Aug. 6, 1827
Greece	Dec. 10-23, 1837
Guatemala	Mar. 3, 1849
Hanover	June 10, 1846
Hanseatic Republics	Dec. 20, 1827
Hawaiian Islands	Jan. 30, 1875
Hayti	Nov. 3, 1864
Honduras	July 4, 1864
Italy	Feb. 26, 1871
Japan	July 25, 1878
Liberia	Oct. 21, 1862
Madagascar	Mar. 13, 1883
Mexico	Jan. 20, 1883
Morocco	Sept. 16, 1836
Muscat	Sept. 21, 1833
Netherlands	Oct. 8, 1782
Supplemented	Jan. 19, 1839
Renewed	Aug. 26, 1852
New Granada	Dec. 12, 1846
Nicaragua	June 21, 1867
Norway	July 4, 1827
Ottoman Empire	Feb. 25, 1862
Paraguay	Feb. 4, 1859
Persia	Dec. 13, 1856
Peru	Sept. 6, 1870
Portugal	Aug. 26, 1840
Prussia	May 1, 1828
Russia	Dec. 1-13, 1832
Salvador	Dec. 6, 1870
Samoa	Jan. 17, 1878
Siam	Dec. 17-31, 1856
Spain	July 22, 1819
Sweden (see also Norway)	July 24, 1827
Swiss Confederation	Nov. 25, 1850
Tripoli	June 4, 1805
Tunis	July 24, 1824
Turkey (see Ottoman Empire).	
Venezuela	Aug 27, 1860

This list includes only those of Commerce and Navigation and does not include Treaties of Peace and Amity.

How far these Reciprocal Treaties have really effected a reciprocation and benefit to our trade—even where most effective—is a question to which we should give careful examination, and it is the duty of every business man to consider the same, as they deeply affect his financial interest.

Since the adoption of our Constitution *one hundred and thirty* Reciprocal *Commercial* Treaties have been made valid, of which *seventy-seven have become obsolete*, and the fifty, recorded above, remain in force. These Reciprocity treaties have been of varied purport, viz.: "Consular," "favored nation privileges," "real estate," "personal property," "privileges to vessels," "merchants," etc.

It would be tiresome to detail the particulars of the good and bad contained in the multifarious assortment of international law that these Treaties present.

True, the Peace Treaty of 1815 established an era of pacification throughout Europe and America. Industrial enterprise and commercial rivalry were actively inaugurated, and, as usual under excitement of competition, every advantage for the securing of trade was studied, and hence the greatest commercial freedom and privileges in navigation were offered by our statesmen to foreign nations in the hope of outrivaling our rivals for the great trade in industry of our recent enemy in war.

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Thus it was that within six months an agreement was negotiated with Great Britain, almost upon her own terms, in peace, after our victorious struggle in war, which permitted her to exclude us in trade from her colonies, and to gain an advantage over us in navigation, under a negotiation denominated the "Reciprocal Commercial Treaty of July 3, 1815."

This Treaty, extended in 1818 for ten years, was afterward renewed in 1827 for time and eternity (?), it seems, as we are still handicapped by its inequitable specifications and prejudicial advantages in favor of Great Britain—*mirabile dictu!*

That antiquated curiosity of American folly of 1815, our Treaty with Great Britain, faces our statesmen of to-day, as well as of the past, as an obstruction to equalization of commercial conditions, and particularly to the carrying trade between us and nations.

It needs no proof to assure us of this fact. That most profound statesman, Daniel Webster, spoke emphatically, and recorded his opinion thereof, and of our humiliation, in ridicule of the errors that make up our present condition.

Mr. Webster said in an address at Baltimore, 1840:

"I do, gentlemen, entertain the strongest belief that the principle of reciprocity acted upon by the Government is wrong from the beginning, and injurious to the great interests of the country."

Mr. Webster was too diplomatic to express his candid judgment while arbitrating upon other conditions with Lord Ashburton; but let those who claim Daniel Webster as an advocate of "Treaties" review his emphatic words here:

"By every Reciprocity Treaty we agree to give to every nation with which it is concluded a right to trade between us and other nations on the same terms as we trade ourselves—to give to the Hanse towns and the other States of the same class the right to fetch and *carry between us and all nations of the world on the same terms as we do, and practically they can do it much more profitably.*"

Here is the secret of England's success — she determined to wield a strong influence throughout the world by carrying the trade of every nation, and this was accomplished through subsidizing her largest steamship companies — which is still continued.

Mr. Webster further expounded the question thus:

"We ought to give to every nation the right of bringing her cargo here in her ships if she gives the like privilege; but, by the Reciprocity Treaties, to give for the carrying of a nation like Bremen, which has but one

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port, all the ports along a coast of 1,500 miles, with 17,000,000 of people, when she has scarcely 200,000 of her own, pray what sort of a Reciprocity is this? It is very much like the horse and the cock, who were walking together. *The cock thought to make a 'Reciprocal Treaty' with the horse —'I will not tread on you if you will not tread on me.'*"

A finer caricature of "Reciprocity Treaties" could not be more dryly or poignantly portrayed.

The great Webster was not alone in his contempt for such international law. The opinion of his successor as Secretary of State is here appropriate; that brilliant and faithful statesman, whose career was suddenly ended by accidental death, Hon. Abel P. Upshur, in his report Nov. 24, 1843, in presenting to President Tyler the condition of agreement creating the "Germanic Association or Customs Union," known as the "Zoll-Verein," referring to Mr. Webster's report of 1841 upon the same subject, and after pointing out the advantages contemplated thereby, and referring to instructions given to our Minister at Berlin, Mr. Wheaton, to establish a commercial arrangement between our country and the states of that Customs Union, viz.:

"To effect the long-cherished object of procuring the reduction of the present duty on our tobacco, secure the continued admission of our cotton free of all duties, and prevent the imposition of any higher duty on rice than that which is at present imposed."

Mr. Upshur points out the advantages offered by this Zoll-Verein and cites in contrast the exactions of England, France and Austria toward our trade relations and adds:

"There is reason to apprehend that if the best advised measures be not promptly taken American commerce will soon be engrossed by the ships and seamen of Europe."

Alas! how prophetic the warning; how true the prophecy to our present condition is the result of this so-called "Reciprocity Treaty of 1815!"

Mr. Upshur continues:

"*There can be no doubt that the cause of this great evil is to be found in the stipulations of our Treaties, which place the shipping of foreign countries on an equality with that of the United States in the indirect as well as the direct trade.*"

It seems difficult to find any defence or excuse for our impolitic provisions, and deplorable disadvantage in shipping conditions.

The Hon. Mr. Beck, of Kentucky, one of the ablest and most

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earnest advocates of free trade, at a dinner in New York city last year, made the following remarkable admission of the disadvantage under which we labor in our commercial relations with foreign powers under our antiquated treaties.

"I am, perhaps, unfortunate in lacking either veneration or respect for antiquated laws. I deny the right — yes, the power — of the Federal Government to make Treaties with foreign nations authorizing them to engage in our ocean-carrying trade upon precisely the same terms that our own citizens may."

This frank admission applies more particularly, necessarily, to the treaty of 1815 with Great Britain than to any other nation, and is a most forcible and patriotic reflection upon our international commercial relations, although the final expression detracts from the good point taken.

But this question is one of so much importance to-day that its discussion has been agitated recently and ably expounded by the Hon. Mr. Morrill, of Vermont, of the Senate, under the following resolution:

"*Resolved*, That so-called reciprocity treaties, having no possible basis of reciprocity with nations of inferior population and wealth, involving the surrender of enormously unequal sums of revenue, involving the surrender of immensely larger volumes of home trade than are offered to us in return, and involving constitutional questions of the gravest character, are untimely, and should everywhere be regarded with disfavor."

That these two distinguished senators, of antipodal ideas, politic and economic, should at least agree in condemning the hypothetical benefits of our so-called Reciprocity Treaties, is certainly a suggestive thought.

HOME MARKETS.

The Hon. Leverett Saltonstall, of Massachusetts, the father of the United States tariff of 1842, in his able report of that year, epitomized free trade and reciprocal treaties. Mr. Saltonstall pleaded that—

"A departure from the policy under which duties on imports have been so arranged as to encourage *domestic industry*, it is feared, would be most disastrous. Foreign nations would flood this country with their productions and destroy our manufactures by depriving them of the home market. The operation of it would be like that of our *reciprocal treaties, as they are called*, under which we have lost a great part of the carrying trade of our own produce."

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This evil has so long been a subject of complaint that it has frequently been recommended that an "auction duty" would check the excessive shipment to our ports of refuse stock of foreign goods sold here at any price and proceeds remitted in specie to the great injury of our business community.

Mr. McLane, Secretary of the Treasury, sent a draught of a bill to the House for this purpose in 1832.

The economy of a home market to which Mr. Saltonstall refers has been discussed in the preceding letter of this series, and its connection with this letter in regular order is here emphasized; Mr. Saltonstall speaks forcibly, further, on page 20 of his same Report, as follows:

"Thus, it is that in sixteen countries of Europe, in which, if anything like reciprocity of terms were observed, over *four hundred thousand hogsheads of American tobacco*, worth, before shipment, about *thirty millions of dollars*, would probably be consumed, the enormous burdens imposed upon the article by the Governments of those countries limit the introduction of it to less than ninety thousand hogsheads; and upon the amount so introduced into their consumption, costing in the United States less than seven millions of dollars, a revenue is charged and exacted in Europe amounting annually to over thirty-five millions of dollars.

"*Without adverting to any other articles*, these instances have been deemed so striking as to call for some notice in our legislation, in the hope that foreign Governments may be thereby induced to reflect upon the propriety of some change in the policy which is so manifestly *destitute of reciprocity!*"

Why was Mr. Saltonstall compelled to make these reflections upon our reciprocity treaties, but because the free trade of commercial intercourse guaranteed was not equitable?

COASTWISE AND FOREIGN SHIPPING.

In coastwise and inland shipping the United States excels every nation of the world, because of the protectorate in wise navigation laws.

In foreign shipping the United States is the most humiliated in the world, because of our neglect to study scientifically the causes and results, *a priori* not *prima facie*, of this great economic.

Canada has shown far more scientific study, or certainly more practical application, than we have in this respect, and the best evidence is that she is making such rapid and sad havoc upon our transcontinental trade that it will not be long before the whole bulk

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of foreign and even a great portion of our domestic freight and passenger traffic will be gobbled up to pass *via* the Canadian Pacific railroad and steamship line westward to Asia and eastward to Europe.

On both sides now, on the Atlantic and on the Pacific, we are flanked by heavily *subsidized* steamship companies; subsidized by the Canadian government to nearly the amount of a million dollars, as well as by millions of subsidy paid by England and more by other foreign nations.

This is denied by the agents of the British shipping interests, who are supported as residents in the United States to fascinate with soft sophistry our general public, *in an educative* way, to make our credulous believe the idea that the government of Great Britain can do our carrying trade cheaper for us and only pay for carrying the foreign mails.

This is deceptive and absolutely untrue, and will, doubtless, be exposed before the next Congress.

America consolidated by railroad continuation from Alaska to Magellan.

From Behring Strait to Magellan we can *prospectively* see a continued and direct railroad communication between the three Americas, although none of us present to-day may really recognize that concentration of economic and sociologic conditions in our day; but if the people of Canada and the several peoples of our sister republics of Spanish blood progress one-half in proportion to the United States we could see it in *ten* years.

Surely, if Canada can appropriate $215,000,000 for the Canadian Pacific Railroad, and go ahead with it as she has, it is by no means a chimerical project to contemplate a longitudinal railroad from the extreme north to the extreme south of our American continent.

But it is to the Canadian Pacific Railroad that I would call your attention.

This railroad, it is feared by many of our people, will rob the United States not only of her transcontinental trade, but also of our little ocean commerce that is left. So it will, if our statesmen lie supinely on their backs and see our commerce, our shipping and our railroad traffic taken from us without putting forth the same

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scientific and economic effort in legislative skill and foresight to protect such interests.

But the Congress of the United States will act. It cannot do otherwise. There is the Canadian Pacific railroad cutting the state of Maine in half.

Already are Canadian railroads, as well as Canadian shipping, protected and encouraged, while our own interests are neglected. How long can this continue? The whole territory of America, north of the forty-fifth parallel of latitude would pass under the rule of the Dominion of Canada if the present aggressions upon us were to continue.

But we owe a duty to ourselves as well as faithful friendship to you, our neighbors.

The railroad condition of the world is as follows:

America	181,000 miles.
Europe	130,000 "
Asia	17,000 "
Australia, about	9,000 "
Africa	5,000 "

Thus it will be seen that America leads the world in railroad enterprise. Of this the United States has 150,000 miles; Canada, 12,000 miles. Here is a contrast in enterprise as in population.

There is so much in this, as especially in shipping conditions that require scientific study, that I greatly regret that in this address it is necessary to confine argument to but a brief review.

CONSULS AND DIPLOMATISTS.

"Commerce is king," wrote Carlyle; but he should have added, the Consul is premier in commerce. Mightier is he who makes the king than he who wears the crown.

The Consul has the power to guide trade and develop an immense economic work for his countrymen.

The Diplomatist has the greater influence in sociologic associations. He passes, as it is said, "the snuff-box with distinguished consideration," and manifests the ethics of intercourse, diplomatically, of course, between two peoples of antipodal tastes and habits, while the consul studies the means of aggrandizing all the commerce (or wealth) of the nation to which he is accredited in the most scientific manner possible.

In this science, as in foreign shipping protection, England has

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outscienced all other scientists of the world, and the people of Canada have displayed similar talent.

This is another of the few superiorities that I am willing to yield in acknowledgment to our disadvantage; but it is one of the benefits that I trust we of the United States may be inspired to imitate by the approaching unification with the people once known as Canadians, as we were once known as Colonists.

The Consul is a power—where he is needed; but there exists at present a line of pickets along our dividing boundary called consuls doing a duty which is really the most preposterous farce that ever was known, except for *nominal* commercial relations and the fees of the post.

Who that has tried to study the commerce between the United States and Canada has not found that the trade passed secretly between the posts of custom-houses is as great as that passed legitimately? Lumber, clothing, animals, eggs, etc., are passed in and machines, implements, etc., are passed out *ad libitum* without duty or equitable exchange.

Of what value are the official statistics between our two governments under such circumstances?

OUR SOCIOLOGIC RELATIONS.

Social economy is a dependent condition—dependent upon the chance to regulate our national and personal welfare of the domestic family, to sustain existence, to accumulate comforts, and to hoard up all excess of income not needed for absolute immediate subsistence, that it may be reserved for contingent reverses or for indulgence of luxury.

In the economic phase of this subject, however, there must be a distinct line drawn between the expenses for necessaries and saving for luxury.

The man who, even by chance, inheritance, or hard industry, possesses wealth and trusts the loan of that wealth to his neighbors on faith without collateral security, hoping and expecting his prosperity to increase according to his happy ideas, would soon find himself the beggar of charity instead of the ruler of millions in personal wealth.

Take from social economy that reliance upon the security of collaterals and the healthy and sure regulation of justice through law prescribed and ordained by the science of political economy, and you rob the domestic circle of that incentive to industry and thrift

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which is animated and guaranteed by the regulation of commerce, whether of small or great degree, under enactment of a politico-economic body of the people, and thereby also rob both rich and poor of prosperity and happiness.

In an interesting lecture before the Anthropological Society at the Columbian University, at Washington, some months since, Prof. Alfred Russel Wallace, of England, endeavored very seriously to teach us that all men could and should live as angels on trust, faith, hope and charity, and this beautiful theoretical creed is earnestly urged by many under the term of free trade. This would be revolution indeed.

Gladly might we accept such tenets as principles of political or social economy in temporal as well as in spiritual affairs were we assured that our neighbors would be as perfect angels as we could easily imagine ourselves to be.

But we are not. Neither man nor woman has yet arrived at that degree of perfection, even with all our progressiveness, in the United States, and certainly not in England, where free trade has been a national doctrine for forty years.

Professor Wallace was beautiful in his theoretical precepts and teachings, but we do not, unfortunately, partake of Divine nature or of those conditions of life essential to free trade relations and interchanges which are claimed peculiar to the isolated isles of Britain.

No wise financier would lend money even upon collateral if a lawsuit was anticipated to be necessary to recover his principal, but would he be willing to trust on faith?

What right in justice to his family? what sense of self-preservation and maintenance of honor would he maintain? how long before he would be ruined, were he to lend without security, or were our politico-economic laws compulsory to lend on faith, or, worse, to make a general division of the hard earnings of a lifetime?

It would be robbery to the poor man's thrift; it would be death to industry.

When the poor man can borrow from the rich without collateral, then that blessed theory of free trade will prevail—but not till then.

"Charity covereth a multitude of sins," but withal not the sin of debt!

Even Christianity is a failure in creating charity for the indebtedness of *one* dime.

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A debt will be remembered by the creditor forever, though perhaps forgotten by the debtor.

This is not a national characteristic; it is an individuality, whether of Jew or Gentile. It was a very ungracious and incorrect reflection in Shakespeare to attempt to cast ignominy in this respect upon the Jewish people through the character of Shylock. The Hebrew people are as charitable as our own.

We must deal with ourselves as we are, not as what we should like to be.

As well might we guide our conditions by the delicate theory of Platonic love or govern ourselves according to the idealistic principles of Zenophon or Aristotle or Zeno, even more beautiful in principle, and as their philosophy teaches man to become, as to be governed to-day by the tenets of those later theorists, Adam Smith, Ricado, Say and Bastiat, who wrote of political and social economy according to the conditions in their age, but which were preëxistent to steam and mechanical development.

RACE AND RELIGION.

Nowhere in the world is a more conspicuous hatred manifested between factions of one people under one government on account of race and religion than is witnessed to-day in Canada. French, English, Irish, and purely Canadian races each retain and maintain their separate and distinctive identity.

Not even in Great Britain were the several races and religious divisions of England, Scotland and Ireland more antipodal in their tastes and habits or bitter in their hatreds in olden times than are the French and the British colonists—the Roman and the Anglican churches—of the Dominion to-day.

Mr. Beaugrand is as positive in his expressed written views of this fact as Premier Mercier is earnest in his eloquent avalanche of oratorical emphasis.

Can any nation prosper as a people under such prevailing feeling?

It is in fact an ill-assorted combination of two peoples under a cold autocratic government, without any softening provisions to ameliorate racial prejudices or animate religious ties.

Canada will disintegrate herself upon her racial and religious conditions, for we see in our neighboring friends at present the anomaly of a predominating race governed under an uncongenial authority.

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In the United States this antipathy cannot exist, as our form of government destroys such feeling of rivalry, because the natural passions of jealousy, dislike, or ambition have nothing to feed upon.

In exemplification of this as a fact we see that many of these very two peoples have migrated into several of our States and are dwelling in peace and prosperity, and Mr. Beaugrand has very truly said that in annexation to the United States—

"The French Canadians have no fear that they would lose any of their present privileges by coming into the Union. 'Whether as a province of independent Canada or as a State of the American Union, we should retain our right to local self-government, and I do not know of any sensible man among our people who desires anything more than that."

Such is the beauty of our Government in contradistinction to that of a monarchial form.

No "orange" nor the "green," nor yellow nor the red, can interrupt our solid blue by racial or religious feuds, but the Stars and Stripes alone can rule as the banner of our republican identity and as the symbol of protection in the development of civilization and elevation of mankind.

IMMIGRATION AND TRANSFORMATION.

Who and what are we, and who are you? is an important reflection.

It would be ridiculous for the people of Canada or the people of the United States to be termed Puritans of England, or Anglo-Saxons, or Celts, or of the Latin race, nor have we an identity with the aborigines of this Continent.

We are Americans!

In this fourth century of America's discovery and name, it is an interesting as well as scientific study to ascertain our component parts and learn in what proportions we are, as a people, conspicuously developed.

When we compare the United States with Canada, in blessings that have accrued to us from wise foresight in provision, in the inception of our Government, "for the encouragement and protection of our industries," we should ponder upon the vast politico-economic advantages that have accrued to enrich our condition, extend and strengthen our influence, elevate our dignity, enlarge our liberality, and to command the respect of the world, and make our country the haven of refuge for industrious humanity.

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The concentration of ingenious brain, the multiplication of thousands of dollars per immigrant in wealth of labor, the purest and richest virtues in industry and thrift have by immigration been blended into our conditions.

But in our "free land" and under "free institutions" does the immigrant expect to find our home doors open or unprotected, our offices and factories unrestricted from intrusion, or as "free" to the customer as to the owner?

The United States is the refuge for the honest prince of industry from every part of the world, and he emigrates thither to better his condition, to elevate his standing, and to give to this posterity the pride and birthright of manhood. He is re-created from the chrysalis of social nonentity into a development under protection in his new life of earnest striving and saving through industry. Subjugation by low wages and humiliation in dress and food, as was the case in his foreign home, would be to rob him of pride and ourselves of economic results.

The international representation and cosmopolitan character of our people through the influence of these wonderful features of political economy is seen by the following exhibits:

1. Of the sanguinary ties blending us together as a people; and
2. Of the economic power thereby contributed to our wealth annually.

The official figures of the last census gave as

The total number having	Irish fathers	4,529,523
" "	German fathers	4.883,842
" "	British fathers	2,039,808
" "	Scandinavian fathers	635,405
" "	British-American fathers	939,247
" "	fathers of other nationalities	1,321,485
" "	native fathers and foreign mothers	573,434
" "	*foreign* residents of both parents native	33,252
Total[1]		14.955,996

The total number having	Irish mothers	4,448,421
" "	German mothers	4,557,629
" "	British mothers	1,790,200
" "	Scandinavian mothers	631,309
" "	British-American mothers	931,408
" "	mothers of other nationalities	1,226,113

[1]It may be remembered that our present industrial strength is only 17,000,000, and at previous census only 12,000,000.

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The total number having native mothers and foreign fathers	1,337,664
" " foreign residents of both parents native	33,252
Total[1]	14,955,996

Thus the largest foreign element intermingled with us is the German, the second is Irish; these constitute nearly 70 per cent of the whole.

The recent remarkable increase of emigration from Germany to this country has excited that great Political Economist, Chancellor Bismarck, and it is not surprising that he seeks to guard his country from the aggrandizement of American industries by an increased tariff upon American meats, by prohibition, and, worse than all, from depopulation and denationality through American absorption by interdiction to his people of migratory privileges.

The official report of a Consul in Germany says:

"This unprecedented exodus is engaging the serious attention of the German economists, and especially that of Imperial Chancellor Bismarck. The former have been calculating the working value of the average emigrant, and state that the services of every laboring man leaving the country may be valued at $1,000; there can be but little doubt that every emigrant is worth that yearly amount to the United States. Computing the wealth the United States acquire by the influx of population on this basis, and estimating the number of emigrants to the United States during the year 1881, as having reached 600,000, the country would have gained in that period $600,000,000."

This reported loss of wealth to Germany is so reliable that it appears the increase of our *industrial* wealth from immigration has been about $800,000,000 yearly, of recent years.

To estimate carefully as to the money actually brought into our country per immigrant, we must first take the average number of adults and find the amount of specie added by this yearly increase of population.

Another German Consul writes on this point, viz.:

"That the following are the figures given me by the police authorities of this port: adults, 9,223; children under twelve years, 2,208; infants under one year, 519; total, 11,960."

This is a just proportion; or take even less, say, 75 per cent only as adults, we have last year, adults . . .	590,000
at a minimum amount per capita of . . .	$100
adding to our country a specie value of . .	$59,000,000

[1] It may be remembered that our present industrial strength is only 17,000,000, and at previous census only 12,000,000.

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Calculating this immigration as a settled part of our people, at the usual average of five per family, and with the minimum family expenses per month $50, and $600 per year, we add at this rate to our wealth yearly by increased circulation of money, about $500,000,000.

The intrinsic motive power for this extraordinary emigration is found in the simple fact that there is an instinctive yearning in man to better his condition and raise his family to the highest degree of education and refinement, and the emigrant sees in the United States the fairest basis of labor and most equitable standard of Christian liberty and political economy.

Thus we see a most powerful influence and benefit to our industry, and a most important point in our political economy through immigration.

In transformation of people our extreme northern states, Maine, Vermont and New Hampshire, in the upper part thereof, there has been for the last ten years a great development, viz., the exodus westward of many citizens of those states and the migration of French Canadians to fill the void.

But this is Canadianizing New England, and, although it has long been in my mind, I prefer to quote from an able article of Mr. A. L. Bartlett, in the *Forum* of August, which covers the point completely:

"How rapidly the French Canadian element in New England, the great rival there of the Irish in numerical strength, and zealous fidelity to the Roman Catholic Church, has increased, is shown by a few statistics from the manufacturing cities. In the city of Lewiston, Me., the children of Canadian parentage almost equal those of American and of Irish parentage combined. In Manchester, N. H., out of a population of 40,000, 12,000 are of this nationality. In Nashua, out of a population of 17,500, 5,500 are of this nationality, a gain of fully one-half in five years. In Lowell, Mass., they constitute one-third of the population. In Holyoke the children of Canadian parentage are to those of American parentage as five to two. In Fall River, in 1859, there was one French Canadian family; in 1874 this class had increased to 6,000 souls; in the next decade that number was more than doubled; and to-day they number there full 20,000. In Woonsocket, R. I., they constitute two-fifths of the population.

In the public schools of Manchester, out of 3,670 pupils enrolled, 1,437 were the children of aliens—French, German, Swedish, English, Scotch, Nova Scotian, Italian, Norwegian, Danish, and Russian. In Lewiston, Me., out of 6,781 minors, only 1,859 were of American parentage, the nationalities of the others being as diverse as those mentioned above. In Holyoke, Mass., out of 6,297, only 843 were of American parentage. In

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Woonsocket, R. I., less than half the children of school age, as given by the school census, are enrolled in the public schools, and the school report of 1888 says:

"The influx of French Canadians in every year is quite large, and it has become a serious question how they can best be assimilated. The education of the masses is with us a fundamental principle. . . . Schools are established, instruction provided that the children of all alike may become useful and patriotic citizens. But do we realize that there are hundreds of children going to school here whose instruction has no more to do toward making them good American citizens than does the instruction of Canadian children?"

It is our form of government which influences good citizenship, the incentive of pride to be elevated.

This is a matter of *as happy* satisfaction, as it is true, and proves the unifying power of our grand government. In connection herewith I especially point to comments upon education on another page.

UNIVERSAL LANGUAGE.

Speech is the most powerful agent in the world; the most assimilating element in life; the most comforting to all sensibility.

It is a happy solace to think of our grand Anglo-Catholic Creed "I believe in the Holy Communion of Saints;" but with the living there can be no communion of thought or mutual interest of purpose without the interchange of soul in one language.

"Two souls with but one single thought,
Two hearts that beat as one,"

can only be realized when the lips speak one tongue.

This is why we of the United States, although so cosmopolitan, are so assimilated and unified; because in every state one language is recognized in all educational and industrious pursuits.

The reason why Canadians are not unified in themselves is because of the want of this influence.

There is no greater mistake of the Roman Catholic branch of the church than the service in the Latin tongue. Were this error corrected the natural sympathy of that solemn form of worship would be far more impressive upon the mind of the listener and far more powerful in winning American converts to that faith.

Let us reflect that the English language is now general *in every part* of the globe. This cannot be said of any other language under the sun. Think of it!

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In America, Europe, Asia, Africa, Australia and Oceanica the English language is heard extensively, if not by a vast majority.

The idea of Volapük becoming a *universal* language is absurd in the extreme.

A language cannot be issued by one man, it must grow naturally with generations.

Who could have made the English language, although the great Johnston, the reflective Webster, and the critical Worcester, and many others have from time to time improved it?

Look at a small table of figures to see at a glance the relative condition of the principal languages to-day:

English,	by about	150,000,000	tongues
German,	" "	70,000,000	"
French,	" "	50,000,000	"
Spanish,	" "	40,000,000	"
Russian,	" " (purely)	32,000,000	"
Italian,	" "	30,000,000	"
Portuguese,	" "	8,000,000	"

The *London Times* recently very pertinently remarked:

"The commerce of the world cannot go on without English. Let the traveler stop where he chooses, he will find the Greek, the Jew, and the Scotchman carrying on business. They transact it, however, in English and through an English firm or an American one. Smaller branches of trade fall to the Frenchman, the German, and the Italian—the Portuguese, as a rule, occupies himself with the leavings of the rest—but each and all have acquired for practical mercantile reasons a sufficiency of English to make himself understood."

To England unquestionably belongs the credit of being the great disseminator of the English language by the control of the greater part of the world's shipping, and it is to be hoped that we Americans will imitate and help her in this great work.

GENERATION AND POPULATION OF THE CONTINENT.

We have looked into the natural condition of our two countries. We must follow the growth of each to know what is likely to develop still further.

It is easy to see our *preponderosity* in population, but which of us has the smartest brain remains to be seen.

The greater generally absorbs the less, but there can be no unification by force or numbers or power.

England's experience with poor old Ireland shows clearly to the

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world that although there may be a coerced *union* there is not unification.

But look at the official figures which show the proportions of both country and people by the following tabulation:

Let us take the figures *in round numbers* of conditions just here.

	Area.	Population.	Density.
The United States[1] . . .	3,600.000 sq. miles	65,000,000	18.
The Canadian States . . .	3,500,000 " "	5,000,000	1.42

And also let us estimate ourselves with Great Britain thrown in with Canada.

	Area.	Population.
The Canadian States, ...	3,500,000 sq. miles	5,000,000
Great Britain, ...	121,000 " "	36,000,000
Canada and Great Britain, ...	3,621,000 sq. miles	41,000,000
The United States, ...	3,600,000 " "	65,000,000

And what are we coming to? Can Canada vie with us in advancement? Certainly not without us, for see the proportionate growth of the two peoples in the past. And what will it be in the future? It is estimated that the rates of increase of population by births over deaths is at present two per cent. Taking into calculation our yearly increase of population from immigration and our past decadal census, we find it to be but a reasonable estimate to predict for the United States — without Canada — in the year—

1900 a population of 85,000,000,

2000 a population (at least) 500,000,000.

This is not speculative, but as likely as it is that the world will continue " to bring forth its fruit," and that mankind continues to produce issue.

What our moral conditions will be depends upon our continued development of good sense and refinement.

Where shall we put this overflowing population except to spread them over the vast and vacant fields of Canada.

EDUCATION.

The chief bulwark of industry, identity and mutual interest in the United States is our public (free) school system; but there is much improvement yet to be made. Political economy and social science should be more generally taught for the higher elevation of

[1] Including Alaska, which has proved to possess great wealth.

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national and local administration and for the better amelioration of domesticity among our people.

Not only is the education of the masses an essential element to the prosperity of a people, but that education must be in our own country.

There is nothing more conducive to unfit the youth for nearly all the paths of American industry than a cultivation of foreign taste and notions in children than a foreign education. Upon this important point I wish to cite the opinion of General Washington, who wrote:

"It has always been a source of serious regret with me to see the youth of these United States sent to foreign countries for the purpose of education, often before their minds were formed or they had imbibed any adequate ideas of the happiness of their own, contracting too frequently not only habits of dissipation and *extravagance*, but principles unfriendly to republican *government*."

The standard of education in the United States to-day is the best and highest in the world.

U. S. Consul Potter, at Crefield, writes to the Department of State, in regard to the unhappy influences upon the American youth studying abroad, especially in Germany, that—

"to such influences none are more sensitive than the nervously organized young American,"

who is sowing seeds for the future — either for usefulness or extravagance.

Consul Potter very truthfully and forcibly adds that "a cultured American who has mastered any single subject of study in America would not (at this date) find much in the same line of study to learn in Europe."

CONSANGUINITY AND MARRIAGE.

There is an influence developing more steadily and progressively which will inevitably prove a much stronger British investment in the United States than any syndicate of the many being formed.

These numerous matrimonial syndicates are investments, however, that will eventually undermine the British government and make Canada and the United States one at heart, one in family and one in home.

It strikes me that these are the wisest investments made by our English cousins; for, though it seems so far to be the case that

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Englishmen get the money and our American girls only get the imaginary crowns or titles, the Englishmen, notwithstanding, obtain most irrepressible rulers, who will wield so developing an influence over them, though they never wore a crown or title before, but who are so thoroughly indoctrinated with Republican principles and associations that it must surely be ingrafted in their posterity—their children and children's children must inherit the spirit of a mother.

POLICY OF ECONOMY THAT CREATES MONOPOLY.

Monopoly is a word of such general meaning, and applied as a term, of such antipodal significance, that when used to indicate economic conditions its sense may or may not be complimentary. If monopoly is used to indicate advantages or preferences in economic legislation, and if such legislation favors one branch of industry or class of people to the injury of the other, that monopoly should be wiped out immediately and entirely; and if such were applicable to protective tariff enactments we should and would abhor and denounce the injustice with earnestness. But wherein is an industrial protective policy a monopoly — when the farmer gets protection on the value of his farm, his horse, or his product?

Then it took a large quantity of his product to buy an English carriage, a clock, or even a plow; it took the value of his horse to buy any small article of machinery, and especially if it was of foreign manufacture.

Now he pays only from five to ten dollars for a plow, and yet his horse has about the same steady value. Now, one-fourth of that part of the produce he paid for any implement then will be ample in value of exchange. Such results may be called monopoly of protection, but such monopoly has not hurt the farmer, the merchant, nor the country.

How purely selfish it is, then, in the Cobden Club writers, and how inconsistent in American statesmen, to appeal to American farmers — as their friends — to believe the doctrines adverse to the farmers' interest!

There is not a branch of industry, mental or physical, that has not been simplified, improved and cheapened; there is not an article of home or foreign manufacture (of iron or any other material), of mechanism or ingenuities, essential to labor and to our wants in trade or household comforts, that have not been made

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cheaper in price; and where is the man who desires to give up the advancement, the independence, the refinement, the education, the thrift and all the blessings brought about by this so-called monopoly.

That monopoly can only exist under *free* trade, and that *free* trade can only exist under the protection of monopoly is unquestionably clear, in the fact that it was only the monopoly of iron that developed British manufacture, the monopoly (throughout the world) of her many and developed manufactures that induced and enabled her statesmen to open British ports as the *sans-souci* marts of inequitable trade.

If industries or trade require protection, it is against that monopoly; hence, the absurdity of the weaker condition monopolizing the greater. It is to destroy monopoly that protection is necessary; it is as necessary to discriminate in the policy of protection as it is discreet to protect only where necessary.

Protection is not for the benefit of monopolists at home; it is to defend us from monopoly from abroad — from foreign monopolists of capital and of pauper labor, from the monopoly of the world's foreign carrying trade, from monopoly of foreign banking exchange and from a foreign controlling influence over our commerce through commercial letters of credit from the monopolizing conditions of the Lloyds Insurance, which alone is a triumvirate of insurance, shipping and official protection thereto through the British consular service.

Monopoly is only powerful where conditions are left *unregulated*, where the greater absorb the lesser, and where the poor are most subject to the rich and influential.

But as a feature of political economy in import duty of our country the truth is recorded in the pages of official history of our country's past.

The power of the *foreign* "Importer's Monopoly" is exhibited in the investigation of the working of the boasted tariff of 1846. The importer of the United States is peculiarly of a duplicate character in his relation to the politico-economic conditions of our country.

It may not be generally known, but of this class of our community seventy-five per cent are foreign, representing foreign capital and foreign industry; twenty-five per cent, only, being the ratio of Americans possessed of home capital, of home ties and

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home interests, nationally or individually, in the importing trade of our country.

It is the former who control a monopoly of our foreign trade, and who with watchful eye antagonize every clause in legislative acts that tend to interrupt that status that they have steadily developed, and the spirit of monopoly evinced since the colonial taxations for foreign staples that drove our fathers to independence in person and protection in industry.

It is not from the latter class of importers that the cry comes for free trade as an economic principle, but their cry is, to be saved from the "undervaluations," the "impure grades," and the "tricks of the trade" that have been made, and will always be made, under an approach to free conditions or deceptive ad valorem rates of custom duties. So ruinous a result from such a system can only be understood from the evidence of those who have suffered, but the importance thereof justifies the citation in corroboration of fact in contradistinction from fallacy or theory.

So far from the industry of manufacture being a monopoly under an economic policy of impost duty, it is conspicuously incorrect to every clear and impartial mind, after careful study of the causes and results in our condition.

On the contrary, the great number and variety of classes who are benefited by such protective system are as fourteen is to four; proportionate to the census return of those who in their industrial occupations have the great benefits of such economic safeguard without the fear of financial risk or apprehension.

A home demand, from a large and steadily increasing custom at our own doors, is far more secure than the patronage of rival foreign nations, whose purchases from us depend upon the contingencies of the production or scarcity of other parts of the world and the prevailing relations of peace or warfare between nations.

There are many causes influencing a monopoly and depression of commercial patronage from foreign nations that are necessarily prejudicial in trade and conducive to a sudden excess in demand and shortness in supply, and also to as sudden a reverse.

Monopoly, then, lies in foreign banking exchange, in foreign insurance, and in foreign shipping, which secures to foreign imports an undermining influence upon our home industry that tends to consume our strength in commercial relations, notwithstanding our resources and home enterprise. Such monopoly, if allowed to de-

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velop, and surely if advanced by abolition of our protecting tariff, will result as injudiciously and ruinously to our people as such causes and conditions have ruined other nations in the past.

CONCLUSION.

An argument is too apt to present individual ideas or preferences; too liable to be based upon hypotheses or sophisms; too probable to be drawn in conclusion omitting some premise of reason or condition, a realism not sophism, that might materially alter the deduction made.

It is easy to accept an argument provided the sentiments expressed meet the sympathy of the listener or reader, but it is hard to make men agree whose immediate interests do not appear to them sufficient to give reflection to questions considered or whose ideas are of a diametrical tendency, although we all know many instances where parties have, after careful study or from some experience felt, learned the mistake they had made in judgment by finding conditions existing that had not before been apparent to them, because either they had been blinded by prejudice or thoughtless of the subject.

This is true even among students of economic science and statisticians in their deductions from official data, and the greatest care and frankness should be cultivated in verification of all those data and of historic records to guard against error and to perfect a scientific research for a conclusion.

An illustration of disagreement to be regretted, especially among economists, as, for instance, Condillac absurdly claimed as a principle of economy that there was an increase of value in the exchange of commodities, because, as he wrote —

"If men always exchanged equal value for equal value there would be no profit to be made by traders."

This is a sophism, and exposed clearly by Jean Baptiste Say, who answers —

"Since a sale is nothing but an act of barter, wherein one kind of goods, silver, for example, is received in lieu of another kind of goods, the loss which either of the parties dealing should sustain on one article would be equivalent to the profit he would make on the other, and there would be to the community no production whatever."

And plainly explodes such fallacy when he says:

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"*The seller does not play the rogue nor the buyer the fool, and Condillac had no ground for his position.*"

Sismondi answers the sophism forcibly, as follows:

"*The trader places himself between the producer and the consumer to benefit them both at once, making his charge for that benefit upon both.*"

Thus we see that sometimes "even doctors disagree!"

It is far from my wish or thought that this brief analysis of the existing conditions and probable eventualities of our two peoples be taken in an autocratic spirit.

Not as Monarchists but as Republicans, and with the progressiveness naturally peculiar, and judging of the future by the past, with careful study and consideration, it seems to us that there is no future for Canada but in union with the United States, which is to-day *first in industry*, *first in educational system*, *and first in wealth* among the nations of the world.

We cannot go to you, but invite you — when you feel that you cannot help it—to come to us; and it seems beyond theory and more than a "glittering generality" to expect it soon for

"No pent-up Utica contracts our powers, but the whole boundless Continent is (or will eventually be) ours."

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APPENDIX.

The following interesting and important comparison of the world's gold and silver product from the "Washington Press" of Aug. 27, was presented in the address.

GOLD AND SILVER VALUES.—AMERICA COMPARED WITH THE WORLD.

	GOLD.	SILVER.	GOLD & SILVER.
Germany,	$11,000,000	$283,000,000	$294,000,000
Austro-Hungary,	242,000,000	293,000,000	535,000,000
Europe,	2,000,000	330,000,000	332,000,000
Russia,	793,000,000	90,000,000	883,000,000
Africa,	376,000,000	1,000,000	337,000,000
Australia,	1,246,000,000	8,000,000	1,254,000,000
Other countries,	126,000,000	81,000,000	207,000,000
Total,	$2,796,000,000	$1,086,000,000	$3,883,000,000

SOUTH AMERICA.

	GOLD.	SILVER.	GOLD & SILVER.
Granada,	$623,000,000	$—,000,000	$623,000,000
Peru,	82,000,000	1,091,000,000	1,173,000,000
Bolivia,	145,000,000	1,517,000,000	1,662,000,000
Chili,	134,600,000	186,000,000	523,000,000
Brazil,	522,000,000		
All other So. Amer. countries,	40,000,000	12,000,000	32,000,000
Total,	$1,546,000,000	$2,806,000,000	$4,352,000,000

NORTH AMERICA.

	GOLD.	SILVER.	GOLD & SILVER.
United States,	$1,806,000,000	$863,000,000	$2,669,000,000
Mexico,	143,000,000	2,995,000,000	3,138,000,000
Central America,	13,000,000	2,000,000	15,000,000
Total North Americas,	$1,962,000,000	$3,860,000,000	$5,822,000,000
Other Americas,	1,546,000,000	2,806,000,000	4,352,000,000
Total America,	$3,508,000,000	$6,666,000,000	$10,174,000,000
Total Europe, Asia and Africa,	2,796,000,000	1,086,000,000	3,882,000,000
Total World,	$6,304,000,000	$7,752,000,000	$14,056,000,000

Percentage of Gold,	86	in favor of America.
" " Silver,	56	" " " "
" " Gold and Silver,	72	" " " "

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PAPERS READ.

THE ECONOMIC CONDITIONS OF LONG-SPAN BRIDGES WITH SPECIAL REFERENCE TO THE PROPOSED NORTH RIVER BRIDGE AT NEW YORK CITY. By GUSTAV LINDENTHAL, C.E., Pittsburgh, Pa.

[ABSTRACT.]

THAT facility and rapidity of communication are a primary cause of civilization is recognized as an axiomatic truth. It is a popular phrase that the civilization of a country or nation may be judged from the number and condition of its roads.

The modern development of any country takes first the form of steamer lines, railroads and telegraphs,—all for rapid communication. It includes the greatest economic problems for human energy and endeavor: the economy of matter, power, time and space. As a special application we all recognize the great convenience and economics of unbroken and rapid communication over wide and deep rivers and estuaries, irrespective of wind and ice, by means of long bridges, and, where necessary, by means of long-span bridges.

The art of bridge-building is ancient; the science of bridge-building is modern.

The bridges of only a hundred years ago do not present any greater merits, if so great, as the bridges built one or two thousand years ago.

The bridge over the Euphrates at Babylon, built in the reign of Semiramis (about 835 B. C.)[1] and described by Herodotus, was as great an undertaking as any that we have records of to most recent times.

The diversion of a deep, navigable stream, 2,000 feet wide, for the purpose of building the pier foundations of that bridge, would also for our time be called a great work, were it necessary to undertake it.

China has stone and suspension bridges many hundred years old, of unexampled magnitude in any other country at much later times.

The limit in bridge construction, which human energy and enterprise could achieve on a merely empirical basis, had been reached long ago. The longest span of a scientifically proportioned stone arch bridge, "the Cabin John Valley Aqueduct Bridge" (220 feet span, built in 1870 by General Meigs, U. S. Army), had been anticipated nearly 500 years before by a stone arch bridge of 251 feet span over the Adda at Trezzo (built in 1380 and destroyed in 1430 by the Venetians). The latter had been built on empirical principles only; at that time the science of mathematical mechanics had not even yet begun.

[1] Other accounts ascribe the building of this bridge to the reign of Queen Nitocries, said to have reigned about one hundred years later.

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The greatest and best of wooden bridges, to fifty years ago, were no greater achievements than was the often described great wooden arch bridge over the Danube below the rapids of the "Iron Gate," built in the reign of the Roman Emperor Trajan, 104 A. D. It was over 4,000 feet long and had 170 feet spans. Remains of the piers, founded in water eighteen feet deep, can yet be seen.

In military bridges, where fertility of resource and determination in the face of great danger are as important as constructive skill, the ancients and the mediævals have not been surpassed. The pontoon bridge over the Hellespont for the army of Xerxes; the pile bridge of Cæsar, built in ten days over the turbulent Rhine and in the face of the enemy; the pile and flat boat bridge, built by the Duke of Parma (in 1584 over the tidal river Schelde, 2,600 feet wide and 60 to 80 feet deep) during the siege of Antwerp — each of these achievements has not been excelled in modern history, considering the resources of the respective times. Human energy, enterprise and intelligence have, it seems, been the same, as far as history can inform us, of the great and powerful nations that have lived and gone; but human knowledge has increased and with it the field of its application.

Stone and wood have been superseded by iron and steel as material for the superstructure of bridges. With the development of the metallurgical arts, with the cheapening of the once costly metals, came their use for bridges in a manner and in a magnitude that would have been considered fabulous two generations ago.

The art of iron bridge-building is less than one hundred years old; the science of bridge construction is less than forty years old — very small periods, indeed, as compared with what it will be in the future. And what has been achieved? While a compendium of bridges ten years ago would hold within a slender volume an account of all the great structures of recent times, these have multiplied to an extent that would fill many such volumes now.

And the time of iron and steel bridge-building has only begun. Imagine what it will be when the second centennial of the inauguration of Washington as first president of the United States will be celebrated!

The North river at New York will be spanned by more than one bridge. The East river, bridged at present only by the magnificent suspension bridge at Brooklyn, will have as many great bridges over it as Chicago has now over its narrow river.

In anticipation of the first bridge intended to be built over the North river at New York, it will be interesting to consider the leading economical principles for long-span bridges in general.

1. SELECTION OF THE BRIDGE TYPE.

The science of bridge-building, having and progressing from a mathematical foundation, enables the engineer to work out results and to predict effects with increasing precision. We can closely calculate the stress in each member and proportion its strength for any condition of loads. We can tell in advance how much a bridge will deflect under certain loads,

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or under temperature effects. We can determine its rigidity, even the extent of oscillation under defined speeds of railroad trains.

The principal types and combination of types, their merits and demerits, are now better understood,

Several kinds of trusses, which only a few years ago were frequently built as having special vague advantages, have become obsolete and have gone out of use. Experience, and a more rational and developed analysis of strains and of the dynamical effects, point to the gradual elimination of other types yet used for construction.

The first long-span bridges, by which may be understood bridges of steel and iron of about 400 feet or more in length, for railroad purposes, have been built in England. They were of the type called "tubular girders," of which the well known Britannia bridge (built 1850) in England, and later the Victoria bridge at Montreal, Canada, with shorter spans, are the most prominent examples. In their design, theory and empiricism were yet intermingled in determining their dimensions. Though very wasteful in the use of iron, in their conception and execution these bridges will always remain monuments of great engineering skill. They must be judged by the standard of their own time. The same bridges, built on modern designs and of greater strength, would require less than one-third of the metal and could be built in less than one-fourth the time for less than one-fourth the cost. Greater bridges are now built as an every-day occurrence. Their cost has been decreasing yearly, though it may not perhaps continue to decrease materially for some time to come.

For spans exceeding 500 feet in length, ordinary truss bridges lose their economical value, and other bridge systems offer greater advantages.

All single-span truss bridges, whatever their form, whether parallel chords or not, whether full or latticed web, or whether the open, large panel web of special American design, belong to the class of beams.

Like any ordinary wooden beam, if lengthened out to cover several spans as a whole or continuous beam (instead of being cut into several single beams, one for each span), iron trusses, when so made continuous over several spans, show increased rigidity and strength and economy of metal. The calculation is somewhat tedious, but this is a matter only for the engineer who builds them and no objection to their use, where reliable foundations can be obtained.

The next type or system, now largely used for long spans, is the so-called cantilever bridge. Like all others, it is very old and has been used in the remotest times, built of stone or wood. It simply consists of two brackets, corbels, or projecting beams, anchored fast at one end and reaching out beyond the supports till the opposite ends meet and are connected. Sometimes a beam is suspended between these ends or supported on them.

The modern novelty consists in the construction of this system in steel and iron. Its application on the largest scale is in the Forth bridge, now nearing completion in Scotland, where the two channels of an estuary, each 1,700 feet in width, have been bridged in this manner for a double track railroad. Numerous examples on a smaller scale exist and are con-

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stantly added to in other parts of the world, particularly in East India and in North America.

The erect arch is, like the former types, also of ancient origin; though for the simple constructive needs of the oldest historical nations, it was not as frequently used as the beam and the corbel or cantilever. The Romans were the first to apply the arch principle to timber bridges, after having used it long before for stone arches. Cast iron was the next material used for arch bridges, the oldest of which was built only about one hundred and ten years ago, namely, the bridge over the Severn at Colebrookdale.

Since then arch bridges in cast iron, wrought iron and steel have been built in all parts of the world, some of them beautiful and very substantial structures, promising to last centuries. But so far no greater span than 540 feet (in the Garabit bridge in France) has been constructed. The arch type lends itself very well and economically to much longer spans than either the continuous girder or the cantilever system, provided the local conditions are favorable for the necessary substantial abutments against which the arches rest.

But the bridge type preëminently adapted for the very longest span attainable is that of the suspension bridge. It is as old as mankind itself and may be even older. Zoölogists tell us of the methods employed by apes in crossing streams. Failing to find a fallen tree to act as a beam or truss bridge, or failing to find meeting tree branches, forming a sort of cantilever bridge, apes, we are told, form a chain by hanging together hands and tails, and suspended thus over a stream from tree to tree, the rest of the tribe climb along this living bridge from shore to shore. The strength of the chain with its weakest link was, in this case, the weakest monkey, and there can be little doubt that occasional failures of such living bridges may have engrafted that bit of wisdom already on our anthropological ancestors. Modern bridge engineering, based on mathematical deductions, could not improve it. When Montgomery in his famous description of the Brooklyn suspension bridge, referred to its ethnical origin in the suspension bridge of the savage — the two stumps of trees as towers, the rope of twisted creepers, fastened at either shore to boulders as anchorages — he described a comparatively advanced stage of remote suspension bridge-building.

We have an account of a Chinese suspension bridge, equal in magnitude of span to Roebling's Niagara suspension bridge (800 feet). It was built of chains in the first century; remains of it still exist.

Since a suspension bridge requires, of all bridges, the least amount of metal, it is quite natural that the first metal bridges should be of the suspension type on the same economic grounds which, to this day, determine its choice. The facility with which they could be erected induced bridge builders to use them for longer and longer spans. The first longest-span bridges were of the suspension type: modern bridge engineering has not discovered a more economical type for the very longest spans. It is, however, a noteworthy fact that scientifically the suspension bridge systems were the slowest to develop correct theoretical application.

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If we consider the economical values for long spans of the five principal bridge types, we find that they are not the same. Lowest in the scale are single-span trusses. They have been built so far to 540 feet spans, which will hardly be exceeded in the future, This is considered their economical limit, beyond which the following types give cheaper and better bridges.

The continuous girder is economical only for a succession of at least three spans, of which the end spans should be at least one-fifth shorter than the middle span. This latter may reach to 2,000 feet for a railroad bridge. Two thousand feet may be considered the economical limit also of the cantilever bridge system. The Forth bridge, now building, of 1,700 feet spans, will likely remain for a long time the longest cantilever bridge in the world.

Spans of 4,000 feet could be bridged, if necessary, with a steel arch bridge for railroad trains. The roadway need not necessarily be on top of the arch as in a stone bridge, but may be suspended from the arch, as in the Douro arch bridge in Portugal. Arch bridges can also be erected without false work, if necessary. Several of the most famous arch bridges of modern design have been so erected, among them the largest, namely, the St. Louis arch bridge, built by the late Captain Eads, and the Garabit viaduct, built by Gustave Eiffel. Both have over 500 feet spans.

But where the local conditions are favorable to a large arch bridge, and particularly to the erection without false works, the conditions will be found, as a rule, favorable to a suspension bridge, capable of the greatest economy of all known bridge types, and the one type capable of application to the longest possible spans. Single spans of over 6,000 feet could be bridged for railroad trains, if necessary, with cables of steel wire having a breaking strength of 170,000 pounds per square inch, which is the strength of wire in the Brooklyn suspension bridge. But steel wire suitable for bridge building can be obtained now having a breaking strength of 240,000 pounds per square inch, if price for the same were no objection.

The choice of the suspension type for the proposed railroad bridge over the North river at New York city is justified:

First. By the local conditions, which require a single span over the most valuable and increasingly crowded water highway in the United States. The unanimous popular and local sentiment is against any bridge which would require one or more piers between the shores. Just as the East river, between New York and Brooklyn, has not been allowed to be bridged, and will never be bridged otherwise than without piers in the river, so the North river, between New York and Jersey City, more important yet as a commercial highway, is not to be bridged except with a single span, or it may be tunnelled.

A river span of 2,850 feet will span the entire river, and the two shore spans will be 1,500 feet each. The bridge will reach over valuable property on either shore, which otherwise would be destroyed and become useless for business purposes. It will be 150 feet high above the water.

Second. The North river suspension bridge can be erected without false works from anchorage to anchorage, for a length of 6,000 feet. Naviga-

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tion and traffic on the streets need not be interfered with during the building of the bridge.

The suspension type is the most economical for the locality. Single span trusses, continuous and cantilever trusses are out of the question for such a long single span, for the reasons given above.

An erect arch bridge is impracticable. The foundations for the abutments would have to be in very deep water. It would be impossible to build them so secure that the thrust of the arches would not cause a yielding of the masonry mass on the foundation. The weight of masonry under water is only about one-half of that out of the water, on account of displacement. The resisting mass would have to be enormously large. But in very deep water it could not be perfectly bonded to the foundation, because of the impossibility of reaching very great depths otherwise than with dredging tools. The pneumatic method of foundation is not applicable to greater depth than about 120 feet. Beyond that the mortality among the working men would increase to a criminal and murderous extent. Some engineers would not risk the pneumatic method beyond 100 feet in material such as the bottom of the North river consists of, namely, mud with sand, with boulders and sand pockets down to deep rock in uncertain quantities, a combination liable to sudden "blowouts."

Fourth. The towers of the suspension bridge, which alone require the deep foundations, have to resist vertical pressure only. The foundations are not exposed to any thrust or other lateral force, as in the case of an arch bridge. The pull from the large cables of the suspension bridge is resisted by the large anchorage masses placed 1,500 feet back of the towers, where the rock rises to the surface. The cables can there be rooted into the rock. No sliding or sheering can possibly take place with anchorage masonry, bonded into the solid rock.

2.—THE NATURE OF THE LOADS OR TRAFFIC OVER A BRIDGE.

The nature of the loads or traffic over a bridge was always held to have a decisive influence on the choice of the type for long-span bridges.

Thus for wagon and street traffic, suspension bridges were considered safe and proper, but when the problem arose of long spans for railroad traffic, the most eminent engineers at first disagreed widely in their judgment. Still it is a noteworthy fact that already in the earliest designs for railroad bridges the suspension type was thought of and seriously considered. Thus the first designs for the long-span bridge over the Menai straits were on the suspension principle, stiffened by plate girders. From tests with models it was then concluded that the chains could be dispensed with for the proposed 460 feet spans if the strength of the girders were increased, and out of the original suspension bridge was evolved the tubular bridge, built as a continuous beam of four spans.

Brunel's bridge over the Saltash, near Plymouth in England, is derived from a similar idea of chain stiffening, but in this case the tube was ingeniously placed above the chain as an arch, the thrust of which equals the pull of the chain, and the bracing placed between them furnishes the required stiffening.

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Roebling's success with long-span bridges for wagon traffic encouraged him to propose the railroad bridge on the suspension principle over the Niagara river. He reasoned that as the jolting of heavy teams on the suspension bridges he had built before produced no noticeable deformation, and that the oscillations became less the longer the span, the smoothly rolling loads of railroad trains would still less affect them. That his conclusions were right can be witnessed daily on his railroad bridge below the Niagara Falls (built 1854). This, however, was not the only suspension bridge built for railroad traffic. There was a chain bridge for a double track railroad in Vienna, built a few years later, which did excellent service for fifteen years. The rigidity provided for it, however, had, as in most suspension bridges, not been sufficient, and although safe otherwise it was replaced a few years ago with a modern arch bridge.

Theoretically, a suspension bridge is nothing else than an inverted arch bridge. The chains or cables take the place of the compression members of the arch. It follows that if the chains or cables were stiffened in the same manner and of same strength against deformation as in an erect arch bridge, both systems should be equally stiff and rigid. As a matter of fact, the suspension bridge requires less stiffening, and with less stiffening is more rigid. Erect arches require lateral bracing to keep them in an upright position; without it they would fall of their own weight. Suspended arches require no such lateral bracing: they keep their form without it; they are in stable equilibrium as compared with erect arches, which are in unstable equilibrium. The weight of that lateral bracing in an erect arch is a large percentage (from ten to twenty-five per cent) of the total weight of metal, which is unnecessary and can be saved in suspended arches. This is an important economic feature in a long-span bridge.

A suspended bridge can be built of any degree of rigidity or without any. It will be safe in any case, though it may swing and oscillate.

For comfort and for fast speeds it is undesirable to have a swaying bridge. It requires stiffening. The different systems of stiffening are not alike in economical value or in merit.

The most frequent system is that of stiffening trusses. In very long spans and for railroad trains they require to be very substantial and become enormously heavy, though by no means as heavy as they would be in combination with an erect arch. They carry no part of the dead or live load; their own load must be carried by the cables. Their sole and only function is to preserve the form of the cables under passing loads. The heavier the cables, the smaller and less frequent is the maximum work of the stiffening trusses, whose weight, however, is not decreasing with the increasing length of span, but is increasing merely at a smaller ratio.

Split the cables and insert between them the web-bracing of the stiffening trusses and the weight of the heavy truss chords is saved. The cables themselves will now act as the chords. They will form a curved stiffening frame, or suspended stiffened arch ribs.

The economy of the system is apparent, and it may be said that it is the most economical for very long spans that can ever be proposed, provided

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anchorages can be obtained without such great cost as to overbalance the economy in the suspended arches.

The suspended arch is no more subject to deformation from trains than the erect arch, as already remarked. But the knowledge that a suspension bridge is safe, whether stiffened or not, has caused many suspension bridges to be cheaply built with insufficient stiffening, and as a consequence the notion has become popular that a suspension bridge is not rigid enough for railroad trains. This is a mistake which modern bridge engineers will not make. Empiricism is at an end as far as the rigidity and strength of suspension bridges are concerned. A truss bridge of any description, a cantilever bridge, or an erect arch bridge, if so badly designed or insufficiently stiffened as most of the existing suspension bridges are, would not stand a single load, and most of them would fall of their own weight the moment they were released from the false work. But a suspension bridge cannot fall as long as the cables and fastenings hold. What lighter bridge for the same load can there be of any one other kind than the one of a single wire rope on which Blondin walked across the abyss of the Niagara river?

The North river bridge is designed on the principle just explained. The suspended arch ribs consist of steel wire cables with the bracing between them—the cables are fifty feet apart. These arch ribs are so designed that they will preserve their form without change noticeable to the eye, even in the case of six processions of locomotives advancing on it on all six tracks.

There are only two such arch ribs, though there are six tracks to be ultimately increased to ten tracks. The reason for this arrangement is as follows: in a single track bridge the two trusses supporting it are strained to their full capacity, more or less, from each train passing over it; in a double track bridge only when two trains meet, on a three track bridge with two trusses, only when three trains meet; and so on to a six track bridge, supported by two trusses or arch ribs, the maximum load occurs only when six trains happen to meet on it. The probability or frequency of trains meeting on the bridge is in a greatly decreasing ratio from a double track to a six and ten track bridge.

A long-span bridge can neither be so heavily nor so frequently loaded as one of short span. An ordinary street car, 16 feet long, has about 120 square feet on which at times eighty persons are squeezed together in a manner not possible on a street or on a bridge. Still the load will hardly exceed 100 pounds per square foot of street car. On a street bridge of 100 feet span, it is conceivable that a crowd of people may congregate which would exert perhaps a pressure of 70 pounds on the square foot average, though for the calculation a load of 100 pounds per square foot is usually assumed, as including the effect of impact, accumulation of snow and ice, etc. But on a span of 1,600 feet, such an average load per square foot from a crowd would be a physical impossibility under ordinary conditions. Thus, if the Brooklyn suspension bridge (having such a span of 1,600 feet) should be loaded at the same rate as assumed for a

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100 feet span, it would take a mass of humanity of nearly 170,000 people crowded together and suspended on the structure between the anchorages. The bridge would not yet give away, but long before only one-fifth of this number could get on the bridge, locomotion would be out of the question, and deaths by crushing in the crowd would be almost unavoidable.

Great, dense crowds rarely cover large areas: they cannot with safety to themselves do so, and therefore smaller assumptions of loads are justifiable for long spans when they would not be for smaller spans.

What is true of a street bridge is in a measure true of a railroad bridge. The length of train and its load will depend on the grades up to the bridge. That load which the two heaviest engines can haul up the grades to the bridge will usually be the limit of live load for a long-span bridge, provided that the train's length is shorter than the span. It is not conceivable in ordinary practice that such trains would follow each other closely on all six tracks at the same time. But the strength of the North river bridge is to be such that ten double-headed freight trains, running on ten parallel tracks — five in, five out — all meeting on the middle span of 2,850 feet, could meet on it regularly without doing the bridge the least harm. It is easy to believe, however, that such a meeting may not occur once in a generation.

This great strength is obtained with comparatively less material than in shorter bridges. The live load forms only a fraction of the dead load. The difference in the strains of the loaded and unloaded structure becomes smaller. Experience and exhaustive tests furnish us with the knowledge that this difference of the minimum and maximum strains has a close relation to the durability of the structure, and that the durability increases as this difference decreases. In other words, the durability of long-span bridges is greater than that of smaller-span bridges, not only by reason of the greatly lessened frequency of the maximum loads, but also by reason of the more favorable relation of the strains from dead and live load.

Examples of this truth we find everywhere; to name only a few, there are the long-span suspension bridges at Wheeling and Cincinnati, with an ever increasing traffic; they are as good as ever. They show no signs of deterioration, while shorter-span bridges of greater rigidity in their immediate neighborhood, built after them, have had to be replaced — they were worn out and unsafe. There is no reason why the existing long-span bridges should not last many centuries if carefully maintained.

3. SUITABLE MATERIAL FOR LONG SPANS AND ITS ECONOMIC FORMS.

As already pointed out, steel and iron are the only materials practicable for the superstructure of long-span bridges. There is no probability of anything else being ever used in their place. Aluminium, which is so often mentioned by enthusiastic progressists as the coming structural material on account of its lightness, elasticity, strength and ductility, will never be used, even if it should cost no more pound for pound than steel. The mechanical value of the best aluminium bars is only equal to that of steel bars of thirty-nine tons tensile strength per square inch. That is, taking

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a steel bar and an aluminium bar, about 23,000 feet long, each would just support its own weight suspended. Aluminium has only about one-third the strength and about one-third the weight of such steel. Aluminium wire shows no increase of strength, while, on the other hand, that same steel, drawn into wire of No. 7 Birmingham gauge, would have a strength of about eighty-two tons. But steel wire of 150 tons strength per square inch can be obtained. Steel and steel wire will forever remain the strongest known materials for constructive purposes. Steel wire is preëminently adapted for long-span bridges. Aluminium will have many uses, but for bridges will not be one of them.

The economical value of steel wire has been enhanced by a gradually cheapened cost and an improved quality. For the Brooklyn suspension bridge, twelve years ago, the proper quality of wire could be obtained only from crucible steel, the most costly of all. At this time, wire, more uniform and just as tough and strong, can be obtained from steel made by the open-hearth process, at less than half the cost. The extraordinary toughness of this material is proven by the test of bending cold to a loop round its own diameter.

In very long spans saving of dead weight is of the greatest importance. Steel wire admits of its being done in an unsurpassable degree.

For the above described system of suspended arch cables of steel wire, the length of span which could with safety be bridged grows to over a mile in length for supporting railroad trains. It is doubtful whether the necessity will ever arise for such a length of span.

The durability of steel wire is as great as that of other iron or steel members, and it is more durable than stone in our climate.

Thus, in Roebling's railroad suspension bridge over the Niagara river, the wooden stiffening trusses were replaced with others of steel ten years ago. The stone towers were replaced with steel towers three years ago, but the original cables still exist and require no replacing, though since the bridge has been built train loads and locomotives have increased 60 per cent in weight, and the frequency of trains has increased at least 300 per cent.

The iron wire cables of the old Smithfield street bridge in Pittsburgh, built by the late John A. Roebling in 1847 (and rebuilt by the author in 1882 with a steel truss bridge of larger spans), did not show the least sign of weakness after thirty-five years of very hard usage. The cables in this bridge were light — only four inches in diameter—and from the heavy traffic over it were strained almost every day to nearly half their ultimate strength. The No. 8 wire (Birmingham gauge) was tested when the bridge was torn down. It showed no diminution of strength. The tests showed from 95,000 to 100,000 pounds per square inch, in spite of the hard usage of the bridge. The cables had never stretched from their original camber. Almost every part of the bridge, from the foundations up, was worn out and decayed, except the wire cables. They were made of parallel wires and wrapped with a softer annealed wire in the same usual manner as all later wire cable bridges, including the largest, the Brooklyn suspension bridge.

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In the North river bridge the cables will also consist of parallel wires, but instead of being wrapped with wire they will be enclosed in a water tight steel envelope one-eighth inch thick, which will be removable in sections for the inspection and painting of the wires.

Between the consolidated wire cables and that protecting shell an air space of about two inches will be left to prevent uneven heating of the wires by the sun. Experience and observation on existing suspension bridges show that the sun does heat the cable unevenly. Certain internal strains are necessarily the result. They are not dangerous and are fully covered by the usual margin of strength, but it is desirable to avoid them altogether, which will be done in the North river bridge.

The diameter of the finished cables will be four feet. There will be four such cables; each two, fifty feet apart vertically, will be braced together to form the rigid arch ribs above described.

The connection of these braces to the cables will differ from those in use in being much stronger and so arranged that the couplings cannot slide on the cables.

The towers will be of the open lattice construction, to present the smallest possible surface to the wind and also for economical reasons. Stone towers are more costly, particularly for great heights.

From the cable arches will be suspended the platform, built of steel and arranged for accommodating ten tracks in two stories, six below and four above. The suspended steel girders, forty feet high, will be auxiliary to the arch ribs in their stiffening effect. Of themselves, they would not be sufficient to preserve the form of the cables, if that function were assigned to them. They would have, as already remarked, to be exceedingly heavy and much higher and would greatly add to the cost of the bridge. A heavier suspended structure requires heavier towers. Their foundations would have to be enlarged and the anchorage masses would have to be increased. The weight of the cables obviously affects the whole structure and its economy. To reduce then the weight of the suspended structure, the suspenders from the cables to the platform will likewise be made of wire cables. They will be six inches in diameter and made of wrapped parallel wires. Their weight will be only one-third that of wrought iron suspenders of same strength.

Another reduction of weight is obtained by leaving off the usual heavy timber ties for supporting the rails. These will rest lengthwise on cushioned bearings directly in troughs of longitudinal steel box beams, so arranged that a train cannot possibly leave the track. A strong wire netting will take the place of solid flooring. It is much lighter, does not retain water or snow and opposes no surface to a wind striking the bridge either from below or above. It will, besides, be strong enough to hold up a wrecked train.

Large as the anchorage masses need to be, and as they appear, their cost is not correspondingly great. If the foundations were on ground which had to be artificially reinforced for resistance to pressure and sliding, the cost of the anchorage would indeed be formidable. But as already remarked, the resistance will come from the unyielding rock itself,

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and the anchorage masses are merely needed to hold the anchors down in the rock by their weight. This weight need not be obtained by costly masonry throughout, but a large part of the anchorage mass will be stone ballast encased in masonry. Its form is constructively and architecturally correct. The anchorage portals will really be tunnels, 300 feet long, and partly open on top, forming a grand and fitting entrance to the colossal bridge.

The absence of a similar portal feature in the great Brooklyn suspension bridge is universally recognized, but may some day yet be supplied.

4. PROVISION FOR TEMPERATURE EFFECTS AND WIND PRESSURE.

Steel and iron expand and contract in our climate at the rate of about one-half inch per 100 feet from a middle temperature of 50° Fahrenheit, or one inch per 100 feet between the extremes of 150° Fahrenheit. This would amount to 28–30 inches in the 2,850 foot span, provided the span were independent of the shore spans, 1,500 feet long. But such is not the case. Here the length of the whole cable, from anchorage to anchorage, must be taken as changing its length and concentrating the effect in the middle span.

The cables rest on the towers in large saddle castings on steel balls, and can move. As a matter of fact, the cable bearings could with perfect safety be made rigid, because the steel towers need to bend only about eight inches either way from the middle temperature to accommodate the changes of length in the cables. The bending strains from this movement in the towers are comparatively very small. The cables of the end spans do not change their form from temperature effects; they are free from temperature strains. The effect is all in the middle span, with a result of a lowering of the structure at the middle of about four feet in summer from what it is in April or October, and a raising of four feet in the winter time, or eight feet between the extremes. The Brooklyn bridge rises and falls two and a half feet, or five feet in all. The change is so gradual that it has very little influence on the grades of the railroad tracks.

The changing curve of the arch causes strains which can be accurately calculated and provided for. For an arch rib with two parallel members, the bending strains are largest at the middle of the middle span, and decrease to zero at the towers. The tension in the cables from the loads upon it is smallest at the middle and largest near the towers. It varies about ten per cent.

The wire cables must, for practical reasons, be made of the same diameter throughout, proportioned for the largest tension near the towers. There would therefore be an excess of strength of ten per cent at the middle of the span. It so happens that the strains in the middle caused by temperature changes require a similar increase in the sectional area of the cable at the middle, so that the above mentioned excess will be convenient to meet it.

This is an important economic question, and is solved in the design without requiring any extra section or extra material in the cables for temperature strains. But there is another difficulty to be provided for; a ribbed

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arch, namely, can act as assumed only if it is free to turn as on a hinge on the towers. Not only temperature effects, but also all train loads would otherwise cause an overstraining of the cables there. It would take the form of one cable exerting a greater pressure on the tower than the other, and carrying a much greater part of the imposed loads. To avoid that irregularity, provision is made on the towers for balancing platforms, which support respectively the lower and upper cable saddles. These platforms are so balanced against each other that the cables under any and all conditions of loading or of temperature changes exert equal pressures, or, in other words, their reactions are always equal. One cable cannot be made to carry more load than the other. They must each carry their equal share, and overstraining of the wires is out of the question. This novel device, simple as it is, requires ingenious arrangements for its perfect working; during erection the cable saddles must be perfectly free to turn when the cables are swung from a vertical to their final inclined position.

WIND PRESSURE.

So far we have considered only the effects of vertical forces or loads upon the bridge; but it must be made secure also against lateral forces, of which wind pressure is the greatest. Indeed it would be very bad engineering which would not take into account the tremendous effects of gales on such a large and exposed structure. We have records of wind pressure lifting a heavy locomotive off the track and carrying it about fifty feet; of a 250 foot span double-track bridge having been torn from its anchors on iron piers and lifted and thrown into the river; of the large 1,100 feet suspended span at Wheeling (before it was as securely anchored to the shores below as it is now) being turned upside down and the cables twisted by a puff of wind hardly noticed in the city itself. Lately the suspension wagon bridge 1,000 feet span, below Niagara Falls, was nearly blown down, because one of the wind guys had become worn and broke at the fastenings.

These occurrences prove that the most unequivocal provision must be made against wind force in a suspension bridge.

While very great wind pressures exert their full force usually only over a narrow path, it is safest to proportion the structure on the assumption of a hurricane blowing squarely across it for the full length. The weight of the structure itself is an important factor for its safety in a gale of wind. Theoretically, a heavy and a light bridge having the same surface exposed to the wind would require the same amount of lateral strength to resist wind. But such is not always the case practically, and theory can be corrected thereby.

It has already been mentioned that a suspension bridge is in stable equilibrium as compared with the unstable equilibrium of an erect arch. This distinction has an important bearing on the sensitiveness of the structure against lateral forces against lateral rigidity.

The weight of an erect arch in a vertical plane has no significance and no influence against wind pressure. Whether it were of wood or iron, it would topple over in either case with the same ease if not specially braced.

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It is different with a suspended structure. The wind pressure, trying to displace it, is resisted by its own mass and weight, and the moment the lateral forces cease it will return of its own accord to its position of equilibrium. The wind pressure, if not counteracted otherwise, could push the suspended structure only a certain small distance out of the vertical, and there it would stop. The greatest danger is with the wind striking the bridge from below and lifting it. This danger will not exist in the North river bridge because of its great weight, of the rigidity of the structure otherwise, and because of the open floor of wire netting which will let the wind blow through.

The stable equilibrium of the bridge will be enhanced in the same manner but in greater degree as in the Brooklyn bridge, namely, by inclining the cables toward each other, or by "cradling." While in this bridge the cables are cradled about five per cent, in the North river bridge it will be ten per cent, or twice as much.

Calculation shows that if a wind pressure of fifty pounds per square foot was exerted against the entire length of middle span it would have the effect of displacing the windward cable, with the structure suspended from it, ten per cent. from the perpendicular, so that the windward cable would then be in equilibrium without the opposing pull of the leeward cable. The wind bracing to be provided for is, then, merely that required to prevent the leeward cable from assuming the perpendicular. This reduces the wind bracing to a minimum. It is in the form of horizontal wind cables, two below and two above the platform. They will be very large—nearly twelve inches diameter—and composed of a number of bundled steel wire ropes.

There is a further arrangement by which these wind cables are always kept taut, independent of temperature changes, which otherwise would cause them to be much slacker in summer than in winter time. At no time will the structure be unprepared to resist a hurricane. It may be so great as to prevent the trains from running over the bridge, but will no more endanger the structure than solid ground.

The towers of steel, nearly 500 feet high, will be so wide at the base and of such rigidity that the greatest wind force will produce no oscillation.

5.—ERECTION OF LONG-SPAN BRIDGES AND ECONOMIC MAINTENANCE.

In the nature of things, very long spans will be only over deep, navigable channels, or over other places making a support for erection from below impracticable. They should therefore be erected without false works. Such is indeed the case with all the systems economically suitable for very long spans.

The continuous girder, the cantilever girder, the erect arch bridge, can all, as already mentioned, be erected without false works if necessary. But in none of them is the erection so convenient and economical as in the suspension bridge. It is here merely the question of erecting the first wire or wire rope over the towers.

In Roebling's Niagara railroad bridge, a small balloon took over the first wire. In the Brooklyn bridge it was a wire rope, which, at the signal of

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a cannon, was hoisted clear from the bottom of the East river high above the mast heads and formed the first connection over the towers.

The cable of parallel wires is then usually built in place, strand for strand, in such exact manner that when finally all the wires are completed into one solid cable, the difference in their straining is no more, if so much, as if the cables were composed of bars solidly and carefully fitted and riveted together.

The method heretofore used for making cables in place is somewhat slow and tedious; improvements and preparations on a larger scale will be justified for the larger cables of the North river bridge, which will hasten their completion at least twice as fast. Special machinery and accessibility to every part of the strands will make it possible to carry on their construction and adjustment by means of electrical contact and signal apparatus irrespective of the weather, summer or winter. The degree of accuracy obtainable in that way would not be surpassed if, instead of the cable, there would be a solidly forged steel shaft throughout, if such were indeed possible. And assumed that a shaft of such size, with a strength of 170,000 pounds per square inch could be made, it would lack the pliability and elasticity of the wire cable, a most valuable quality for the durability and strength of the structure.

How long will such a bridge last? It is an unanswerable question in the present state of our science. If well maintained under the most competent engineering superintendence, there is no reason why it should not last as long as the Egyptian pyramids. They were built of more perishable material than steel and iron are, provided iron and steel are kept well painted and free from rust. Rust and man are indeed the only destructive agencies for such a structure. No tornado could blow the structure over. No earthquake could shake it down, unless it were so great that the rock would cave and split and swallow up the North river. The structure cannot be worn out by traffic, no matter how heavy locomotives and cars may yet be used. The heaviest cannon that could be transported over ground could be transported over the bridge. But let the structure be neglected; let it be assumed that this race and this nation die out and this country be again inhabited by savages, and the bridge would decay together with the civilization that produced and maintained it.

It is not likely that war between civilized nations would sanction the destruction of such a structure by bombardment. It would be needless, since the river itself could not, at the same time, be destroyed for communication from shore to shore. Civilized warfare protected the cathedral of Strasburg during the siege of that city; it protected the beautiful and monumental public buildings of Paris. (Their subsequent wanton destruction during the reign of the Commune was not by the enemy of the nation, but by the enemy of civilization.)

Man is more destructive to structures than decay and rust. The necessities of war may bring about the destruction of large bridges in the future as has happened in the past. This may not always be an unmixed evil, if inferior structures are destroyed and rebuilt by grander ones. The

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taste and desire for architectural harmony are growing, though as yet the standpoint of utility, without regard to appearance, is too prominent in most of our bridge structures.

The majestic grandeur and beautiful outlines of a large suspension bridge must be seen to be appreciated. Whether it be the serene and simple architecture of the Brooklyn bridge or the ornamented Buda-Pesth suspension bridge with its link cables and with its exquisitely proportioned stone towers and anchorages, or one of the less noted suspension bridges, no other bridge architecture is more pleasing to the eye and the desire for their preservation is instinctive in civilized man.

There is no cause so insidious and so sure as rust. The alleged gradual crystallization of iron and steel under strain, which was once assumed as a cause for their wearing out, is a fable unworthy of scientific recognition. There are deteriorating causes at work to weaken the cohesion of these metals when abused and overburdened with work by unscientific design; but a modern steel and iron bridge is not a structure of that kind.

Keep out the rust, and in thousands of years the structure will yet stand. And if rust, or other causes, should endanger it, there will be engineers to replace the structure piecemeal without stoppage of traffic. It has been done already on a smaller scale with the Niagara suspension bridge and with others. Besides, it will not be then the first and only bridge over the North river. Others, and may be larger ones, will span the river and connect the shores in the then greatest city, not only of this continent, but of the world, past and present.

Eighty years ago there was on exhibition in the city of New York a model of a proposed wooden bridge, partly cantilever, partly arch, over the East river, of 1,800 feet span. Thomas Pope, an ingenious and ambitious shipwright, was the designer and originator of the project. He was also the projector of a single-span bridge over the North river, which he describes in quaint verse and from which we quote:

> "Like half a rainbow rising on yon shore,
> While the twin partner spans the semi o'er,
> And makes a perfect whole that need not part,
> Till time has furnished us a nobler art."

Since his time this "nobler art" has become a fact and an exact science, enabling us to carry out in steel and iron what he proposed of wood, with absolute certainty of result and of a magnitude that even he, Thomas Pope, a man far in advance of his own time, never dreamed of.

ADDENDUM.

The North river bridge referred to in the foregoing paper, is intended to be built from Hoboken across the river to some convenient point near Fourteenth street, in New York City. A glance at the map will show that this is the narrowest part of the North river in a length of over fifty miles, from Peekskill on the Hudson to the mouth of the river at the Battery in New York City. The river can be bridged here in one single span

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cheaper than it could be done with a pier in the river, because it is here over 200 feet deep to the rock foundation.

A single-span bridge 2,850 feet wide and 150 feet above the water will not interfere with navigation.

The physical obstacles to the construction of such a long-span bridge seemed insurmountable. But there exists now no doubt whatsoever as to the feasibility of such a structure.

The North river bridge is very pressingly needed for the accommodation of the travelling public, arriving or departing on the railroads now terminating in Jersey City, opposite New York.

Every one knows that the present manner of landing the passengers in New York is antiquated and dangerous.

The two tunnels building at present will prove to be a great benefit to local travel, but cannot be expected to solve the problem of railroad crossing. A railroad bridge for ten tracks and with a footwalk promenade will meet the necessities of perhaps only the next thirty years, when another bridge may be needed.

Mere figures would not give an adequate impression of the gigantic work, but some idea can be obtained from a comparison with the great East river bridge, as will be seen from the following data:

	Brooklyn Bridge.	North River Bridge.
Length including anchorages	3,700 feet.	6,500 feet.
Height of anchorages	85 feet.	210 feet.
Weight of each anchorage	60,000 tons.	660,000 tons.
Length of each land span	930 feet.	1,500 feet.
Length of middle span	1,600 feet.	2,850 feet.
Size of towers at high water mark	140 x 59 feet.	340 x 180 feet.
Height of towers from high water mark	272 feet.	500 feet.
Height of towers from the deepest foundation to top	350 feet.	690 feet.
Width of bridge	85 feet.	86 feet.
Height above high water	135 feet.	155 feet.
Number of cables	4.	4.
Length of one cable	3,580 feet.	6,100 feet.
Finished diameter of cable	15½ inches.	48 inches.
Number of railroad tracks	2.	6 to 10.
Grade of bridge	3½ per cent.	1 5-10 per cent.
Allowable speed of trains	10 miles per hour.	30 miles per hour.
Cost from anchorage to anchorage exclusive of land damages	$5,600,000.	$15,000,000.

THE FALL IN THE RATE OF INTEREST. By GEORGE ILES, New York, N. Y.

[ABSTRACT.]

FACTS regarding the fall in rate of interest. Causes,—approximation to European rates through perfected means of communication, and perception by foreign capitalists that the productive and manufacturing supremacy of the world now centres in the United States, whilst invest-

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ments in America are free from risks of war or revolution; that accumulation of great wealth by a comparatively small class has taken place is increase of capital in American hands through rapid development of resources; increase of late years in the ratio of savings offered for investment through increase of savings-bank facilities, building associations and insurance companies; increase of efficiency in production of capital throughi mproved machinery, mechanical and chemical processes; diminution through competition of the rate of business-profit out of which interest is paid.

Effects,—as interest is a lesser share of produced wealth than formerly, wages and rent are larger shares. Facts in proof. Increase in original outlay for railroads, buildings, etc., that expense for maintenance, etc., may be reduced. Rents in the main, a larger ratio of national income than ever, but are less than they would otherwise be since the interest payable on buildings, manufacturing and mining plant, is steadily declining. Accumulation of great wealth by a comparatively small class, who wish to avoid the direct control of investments, has led to a difference wider than ever between the rate of interest receivable on the best securities,—those of the federal, state and civic governments,—and the rate receivable by banks for discounts.

Capital now needs some new form of large investment which will effect some great economy or eliminate some great waste, and provide prime security.

Suggestions: the thorough improvement of towns and cities, as such, by perfecting pavements, sub-ways, means of transportation, etc.; national afforestation, reclamation of arid plains. Brief comment on difficulties in carrying out these projects.

NATIONAL INTEREST IN NATURAL RESOURCES. By Prof. B. E. FERNOW, U. S. Department of Agriculture, Washington, D. C.

[ABSTRACT.]

ALL theories of government agree in its object being the security of society. Logically, this involves also the continued welfare and security of society in the future. Whatever, therefore, affects the future welfare of society must be of present and direct interest to government. Even the advocates of *laissez faire* would recognize the necessity of anticipating dangers rather than wait until conditions become unbearable, before calling for state interference. Continued welfare of society is mainly dependent upon the natural resources. These are squandered; have in many parts of the earth been exhausted or are near exhaustion—examples are adduced—and rational state action in reference to them becomes more urgent. The quality and degree of control by the state must depend upon the relative significance of the resource and the fate it is liable to have

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under unrestricted private control. While each individual case must be adjudicated with reference to special conditions surrounding it, a general point of view may be gained from the following classification:

(*a*) Resources, which yield directly necessaries or conveniences of life and form objects of industrial activity.

(*b*) Resources which serve indirectly for the comforts of society or form necessary conditions for industry and progress of civilization, but do not form objects of industrial action.

The former class may be divided again into

1. Resources, exhaustible, not restorable, upon which the so-called extractive industries are based.

2. Resources, restorable, but liable to deterioration under increased activity.

3. Resources, restorable, and apt to yield increased returns to increased activity.

As to state activity with reference to each of these classes, the second principal class falls naturally under direct state control. The same is claimed with reference to those resources which are exhaustible and not restorable. Those which are only apt to deterioration under the wasteful methods of competition require checks of private activity, while in those which yield increased returns to increased intelligent labor, without exhausting the resources, the interests of the individual and state run on parallel lines and call only for the ameliorative functions of the state.

Soil, water and climate are the three principal resources. Society is the natural owner of the soil, but this exclusive ownership does not need to continue, since the fertility of the soil presents one of the resources which is restorable and yields increased returns to increased labor. But to secure the proper appropriation of the soil to productive uses, averting land monopolies, is a proper function of the state. Water and climate, which supplement the resource of the soil and whatever conditions influence them, must be under direct control of the state.

This involves a rational forest management and reforestation of denuded hills; plains and forests which act as such factors upon climatic or water conditions must belong to the state.

Whenever state action is to be based upon theories on the relation of natural forces and phenomena, the conservative theory as the logical one for society should prevail over the radical and destructive one. Systematic procedure in state action with reference to natural resources is urgently called for.

WHAT SHALL WE DO ABOUT SILVER? By S. DANA HORTON, Pomeroy, Ohio.

Who are "we" that are to do something about silver? What are the active forces of which I am to speak? Am I to set forth what I think we, the people of the United States, or of Canada, should do about silver? It

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is only at elections that the people can act, in the proper sense, act as one united force, and I am not aware that there is any election at hand. I may, however, say in passing, that if there were elections at hand, I should only need to repeat the substance of certain planks of political platforms about silver which have been actually adopted; for example, by the Republicans in the state of Ohio in 1877, by the National Republican Convention in 1884, and by the Republican and Democratic conventions in New York state in 1885. The first mentioned is a recommendation, while the latter are a ratification, of the policy adopted by Congress in the second section of the act of February 28, 1878. This is not the section compelling the compulsory coinage of silver dollars; it is that by which the United States inaugurated a policy of restoration of silver to its former equality with gold by joint action of nations.

This policy, which by its nature combines the elements of a domestic policy and a foreign policy, has remained since 1878 a settled policy of the United States. I venture to believe it is as firmly in the saddle as the Monroe Doctrine. So far, then, as the United States as a whole are concerned, I shall not undertake the task of making suggestions about anything it may need to do with reference to silver.

Nor shall I ask what the several branches of the legislative powers that be, whether the senate or the house, or this committee thereof or that, have to do on this subject. Nor shall I venture to discuss before you the possibilities that lie before the president or his ministers in this regard. No doubt there are essays to be written which might rightly hope to attain such an audience. But there is no need now to go beyond the limits of this room, or the list of the members who belong here, to find ample work to be done, good work, work of conversion, for the advancement of science, work that all the members are pledged to wish well to. The "we' of whom I speak, then, are the members of the section of political economy and statistics of this Association. I conceive they have something to do for their fellow-men in regard to this matter of silver. The silver question covers something more than a scientific generalization waiting to be proved, a compound waiting to be analyzed, a discovery waiting to be verified—for all these can wait. But the silver question involves a duty to be performed, and to wait is to neglect that duty. Moreover it is a duty which the interpreters of science now living owe it to themselves—to the cause of learning—to perform without delay.

Be it known to all friends of science—and never forgotten—it was science which engendered the silver question with the dangers and anxieties that have come in its train. It was the mistaken learning of 1867, of 1871 and 1873, which did the damage that the settlement of the silver question is to check, and, as far as may be, to replace. It was upon the incital, and with the approval, of an overwhelming majority of the learned of all nations, that the statutes and decrees of silver outlawry in various nations became fact. Americans must take to heart that for this error of policy the United States have their share of moral responsibility, for in 1867 the influence of the American Union in the family of nations was militant in

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Paris, aiding and abetting the anti-silver movement then organizing. And all was done with the best intentions, and under the advice of counsel recognized as learned in the law.

What "we have to do about silver," is to educate public opinion and then to advance science, to learn and to teach important truths relating to money —for silver is money and has been since the economic world began—important truths, I say, truths that will assist the present generation of citizens or legislators to safeguard their higher interests by what they do or leave undone with reference to it.

What are these truths? The first truth of all, first because simplest and at the same time universal, *prima inter pares*, is that the policy of federation for equality of the metals before the law—which is the American policy, if our brothers of Canada will permit us, *vis-a-vis* to Europe and Asia, to represent the continent—is right.

I may add in parenthesis that they can the more willingly permit us to do this, since they are in some measure committed in favor of that policy. Such at least was the impression which the highly appreciated ally of the United States delegation, Sir Alexander Galt, conveyed to the members of the international conference at Paris in 1881.

The policy of federation to restore silver to its former legal position, the policy of establishing and maintaining parity between the two halves of the world's money, is right. The union of an effective majority of nations to close a period of disastrous economic conflict and disturbance by a catholic measure of peace and order, is a good work. Once achieved, even a nation may be proud of its share in it. There is enough of barbarism and dulness within sight in our time to serve as a foil in this enterprise of civilization; and individuals who contribute their little quota toward bringing it about need to have their labor brightened if not lightened by appreciating the quality of it.

The project passes slowly towards achievement—slowly, for it must triumph over both the prejudices of men and the inertia of nations. But it is progressing, and progressing fast, now at length that the harvest of conversion in England is coming into sight—conversion in England which alone has blocked the way; for in 1881 the attitude of Germany promised her readiness to join with France and the United States in full when England should do so. The time, then, is approaching for realization of the project proposed in 1878, the time when civilization is to make a forward step, reaching a free mint and a united standard.

What the members of this section "have to do about silver" is to recognize, and upon occasion to teach, the basis of truth and fact upon which is reared this policy of federation to secure legal equality between silver and gold.

I shall try to characterize briefly this basis of truth and fact by a rough sketch map, political rather than economic, giving practical generalizations rather than their scientific sub-structure.

I shall offer an affirmative statement on the following lines:—

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AFFIRMATIVE STATEMENT.

I.

THAT SILVER AND GOLD ARE THE MONEY METALS, AND THAT GOLD IS MONEY AND SILVER IS MONEY TO-DAY.

Of the above affirmation, I select as the only probable object of denial which calls for encounter, the statement that *silver is money to-day*. Are the members of this section all fully aware of this? I hope they are, but I fear they are not; I fear there are exceptions. I have had the opportunity of meeting, in books or in conversation, the minds of most of the learned of our century who have dealt with monetary questions, and I have found in all that goodly company few who entirely realized—in the subtle yet most important sense in which the phrase is now to be used—that silver is money. This sense or meaning of the phrase springs from the internationality of money; the solidarity of interest, the effective contiguity, or the continuity of the various systems of money (which make up the total money of the world), whereby each has an interest in all, enjoys the lateral support of all, and each serves in part as a means of business communication with the other. There is here a truth which is far from having completed its struggle for recognition. Indeed, the concepts in use to-day in monetary discussion are curiously adapted to veil it from the understanding. What with "Single Standard" and "Double Standard" and "Bimetallism" and "Monometallism," it is singularly easy to ignore the internationality of money. Then again, there is the word "Demonetize." What have we not heard of eloquence about the demonetization of silver, and yet, in spite of this demonetizing devil and all his works, silver is money. So likewise, one might say, for generations men have heard of the conquest of Russia by the great Napoleon—the remarkable thing about which was that it never occurred.

There have been local acts, and partial acts, of outlawry against silver, acts which have done more harm to the erring constituency of gold than to the constituency of silver. But that is all. It is ten years since Germany gave up trying to "make soup out of hot water alone," as Bismarck described it, and abandoned her sale of silver made of melted thalers.

In closing, a word of definition rather than argument concerning the supply of silver. Silver is a money-metal. The annual find of new metal has never been more than a minute fraction of the existing stock. In spite of silver mares' nests, whether in Australia or in the Americas, there is no valid ground for expecting any real revolution in the conditions of supply, nor even that the fluctuations of silver output will equal

Note.—I wish to give notice to any one seeking information touching the measure proposed in 1878, that the document of the Monetary Conference of 1878 is still gratuitously distributed by the Department of State, by mail, upon application to the chief clerk.

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those of gold in the past. Hence the stock in existence—that is to say the economic "supply"— is a limited supply; a monopoly of nature not to be broken down.

II.

THAT PARITY OF MONEY IS DESIRABLE.

This affirmation is not unnecessary, as an unbiassed mind might suppose. There are most serious obstacles to logical thinking on this head. The mental vision of our time suffers largely from what I will imagine an oculist calling "atrophy of the apparatus of accommodation," or that there is normal sight, but it is only in spots.

A criss-cross of premium or discount between the moneys of different centres of business is an abomination to the economic mind in every professor's study in the world, provided the places are near each other, as, for example, New York and Philadelphia, or London and Manchester, or Paris and Marseilles. The same truth has vogue when applied to Paris, London, New York, and San Francisco. This kind of organized disorder or Babel of valuations—a financial St. Vitus' dance—is recognized as a grave malady by all regular physicians. Here there is no help but in parity. But how is it with parity between Asia, Europe and the Americas? Here the light grows dim and all signs seem to fail. The lapse of logic is as great as if the regular pharmacopœia should allow its prescriptions to be used only for people in the retail trade.

III.

THAT IT IS THE LAW OF EACH NATION WHICH DETERMINES WHAT IS MONEY IN THAT NATION.

To a public which has passed from state bank notes to silver certificates, it is unnecessary to expand this thesis.

IV.

THAT THE PREPONDERANT EMPLOYMENT — THAT IS TO SAY ECONOMIC "DEMAND"—FOR SILVER AND GOLD IS AN EFFECT OF THE LAWS OF NATIONS.

This is a simple corollary of the preceding. To one who is attracted by the subtleties of causation and of motive, I can briefly suggest two queries. Do legislatures make certain material legal tender because individuals like certain kinds of ornament? Do not individuals choose ornament in part because of the costliness of the material, and of its immediate convertibility into money?

V.

THAT MONETARY LAWS ESTABLISH PARITY.

In establishing money of different kinds or denominations, such laws invariably seek to determine the relation of these kinds or denominations. If they are wise laws they succeed. A law which makes twenty-dollar

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notes and one-dollar notes equally legal tender, effects an equation between twenty ones and one twenty. If one denomination were made convertible and legal tender, while the other is neither convertible nor legal tender, the nominal equation is likely to be falsified by a discount on the one or a premium on the other.

VI.

THAT PERMANENT PARITY BETWEEN SILVER AND GOLD IS PRODUCIBLE BY A PROPER REGULATION OF THEIR EMPLOYMENT.

As has been stated, the stock-in-existence—that is to say the economic "supply"—is limited. To regulate the relative "demand" is to regulate their relative value.

VII.

THAT CONCURRENT LAWS FOR LEGAL EQUALITY OF THE METALS IN AN EFFECTIVE MAJORITY OF NATIONS WILL ESTABLISH PARITY OUTSIDE AS WELL AS WITHIN THEIR DIRECT JURISDICTION.

Ample experience justifies this averment. In late centuries the fluctuations of relative value were fluctuations within the range of effective legal ratios. In this century, so long as the mint of Paris was open (before 1873), there has been substantially parity at Paris, and the local fluctuations elsewhere were chargeable, substantially, to "exchange" on Paris. I say "substantially" to make room for dealing fairly with misapprehensions current in relation to this point. Without entering into detail, I will briefly mention that I have discovered the proof that standard gold bullion has fluctuated in London in this century, as against standard gold coin.

If the great powers and their probable allies give legal equality to silver and gold (of course at the same ratio) their parity at points outside of the direct jurisdiction of these nations cannot be prevented (though there may be fluctuations of "exchange") for it is the "law of supply and demand" which operates as a guarantee of the equation.

VIII.

THAT SUCH PARITY BENEFITS EACH NATION BY ASSURING COMPARATIVE STABILITY TO THE VALUATIONS IN WHICH IT IS INTERESTED.

The benefit applies in various directions and degrees in different nations, but there is something like equality in the shares of the nations in this benefit, because of an equality in the ratio of such benefit to the total economic interests of the nation.

IX.

THAT FEDERATION IS A CONDITION AND A GUARANTEE OF SUCH CONCURRENCE OF LAWS.

This natural view, which guided the Government of the United States and afterwards that of France, in approaching other nations on the sub-

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ject, is supported by the subsequent inaction of nations. Each is unwilling to move without the other, and it is only accord which will make it safe to break the vicious circle.

X.

THAT THE PARAMOUNT MONETARY ISSUE OF THE AGE IS WHETHER A SETTLEMENT ON THIS BASIS SHOULD BE MADE.

There is no alternative to this settlement, which under the guarantees of federation gives parity through concurrence of laws, but the perpetuation of the evils of that instability in the foundations of business and investment of which mankind has had ampler experience since 1871 than at any period since the Thirty Years War. The mere delay fostered by opposition to settlement creates obstacles to settlement. The opponents of the federation policy are in a double sense friends of disorder.

THE DIS-UNIONIST, OR ANTI-FEDERALIST POSITION.

Those who oppose the growth of opinion in favor of Federation may be conveniently classified as follows:—

First Grouping.

Those who have learned only a part of the truths hitherto set forth.

Those who have refused to learn any of these truths.

Second Grouping.

Those who think the federation project will never be adopted, chiefly because of the expected continuance of England's refusal to coöperate.

Those who think the federation would not maintain parity between the two metals even if England were to coöperate, with free coinage of an English silver dollar.

I hope that my friends in the dis-unionist camp will find nothing to offend them in this classification. One who has been militant, as I have for so many years, naturally attains what I may call a certain perspective in regarding the position of his "friends the enemy," and their Parthian campaign of retreat has been full of instruction. In fairness I may confess that the key-note of what I have been saying was given me by one of the highest names in the camp of the opposition and in the literature of money, for Michel Chevalier is among the prophets for all who have a monetary faith. It was by another anti-silver champion, I should also add, by Esquirou de Parieu, the economic adviser of Napoleon III and father of the Latin Union, that I was introduced to Chevalier. The distinguished author of the first great Treatise on Money said to me, "*You will never get England to join.*"

THE RECEPTION OF THE FEDERATION PROJECT IN EUROPE.

I have said that the harvest of conversion in England is now coming into sight. It is a harvest that took a long and weary seed-time, after a

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long and weary breaking of the ground. England was unfortunately busy with other things, and she remains busy. She could not leave Ireland in order to study silver and gold: one might say she could not stop worrying, or worrying about, Ireland, according as one's sympathies are Liberal or Tory. In less troubled times she would have been free more quickly to learn new truths, or rather to recognize old truths in the garb which new experience lends them, and thus would not have blocked the advance of a reform of which she is to be the chief beneficiary.

The advance of opinion in England on the subject presents itself in the following successive stages:—

1. *The attitude of the English representatives at the Monetary Conference of* 1878.—The speeches of Mr. Goschen, at Paris, put the veto of English science and sagacity upon the further rejection of silver money upon the continent. This, logically, was not only an abandonment of the case for England's anti-silver laws, but operated as an admission that the opposite of such rejection, the restoration of silver (proposed by the United States) was a measure which would benefit the United Kingdom. It was an affirmation of the internationality of money.

2. *The attitude of the English representatives at the Monetary Conference of* 1881 was an advance beyond this position. Although promising no further change in the local system of Great Britain than the acceptance of silver as a deposit for Bank of England notes up to the limit of existing statute, to which was added for India the maintenance of free coinage of rupees, the recognition of the interest of the Empire in the policy now proposed by two great powers was made more clearly and more strongly. An analogous admission was contained in Germany's offer of coöperation. As a sequel the silver question was left at England's door. It was plain that under no circumstances could the accession of Germany offer as important a consideration to France and the United States to induce them to establish concurrent free coinage of silver as the accession of England, and at the same time that Germany's adhesion would follow that of England.

3. *The work of agitation and education in England.*—France and the United States not finding that the situation warranted them in restoring silver mintage, it was incumbent upon those interested to set on foot in England a work of education and agitation which should at length secure the desired change in her policy. The International Monetary Standard Association (Bimetallic League) in England, and the Internationale Doppel-Wachrungs Verein in Germany, were founded in the interval between the adjournment of the Conference of 1881 and the date of its intended reconvocation in 1882. Since then public-spirited men have been rallying to the cause from time to time, and the doctrine of monetary union, and parity of the money metals, has been preached in the highways and byways, and in the meantime the evils which we had prophesied have been descending upon England, and have given cumulative force to the teachings of reformers.

I may conveniently mention here a measure of external strategy which

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has been amply urged as efficacious for the ripening of conviction in England, namely, that the American Congress should fix a limit to the continued mintage of new dollars. In the never-ending strife in America between those who saw only the silver side of the shield and those who saw only the gold side, the merits of this great stroke for the cause of silver federation have failed of practical recognition. The event has justified the arguments of its advocates. The results obtained in England to-day—the present strength of the pro-silver movement in England—are proof that the fixing of a limit to the mintage of new dollars, under proper conditions, would have acted as the strongest pro-silver measure within the reach of Congress. Failing this reinforcement, the slower processes of education and agitation were continued.

4. *The Royal Commission on the Depression of Trade and Industry.*—An overt act appeared when the Royal Commission on the Depression of Trade and Industry was appointed in 1884. Among its members was Mr. Gibbs, Director and former Governor of the Bank of England, the President of the Bimetallic League. Its final Report was made two years later, in 1886. In its diagnosis of economic malady the disturbance of the money basis of trade and industry was marked as a region which deserved to be explored by a Special Commission.

5. *The Royal Commission on Gold and Silver.*—Such a Special Commission was proposed to Parliament, and was appointed on September 6, 1886. Its Report (presented November 8, 1888), based upon volumes of evidence and exhaustive study by men of distinguished competence, is a memorable landmark in the advancement of science. It is an achievement of moral as well as intellectual dignity. With it the doctrines which many of its members had been wont to hear denounced as heresy, if not as lunacy, have become admitted truths of monetary science. In the limited space at my disposal I will merely mention that the conclusions of the Report afford an ample platform for the education and agitation conducted by the Bimetallic League, and as a specimen I will add an extract from the Report which was signed by the six so-called "gold men" of the Commission.

Part II, Sec. 107.—"We think that in any conditions fairly to be contemplated in the future, so far as we can forecast them from the experience of the past, a stable ratio might be maintained if the nations we have alluded to were to accept and strictly adhere to bimetallism, at the suggested ratio. We think that if in all these countries[1] gold and silver could be freely coined, and thus become exchangeable against commodities at the fixed ratio, the market value of silver as measured by gold would conform to that ratio, and not vary to any material extent."

Note.—The Report (without the evidence) was printed by order of the Senate at the last Session of Congress (50th Congress, 2nd Session) as Miscellaneous Document, No. 34.

Two of the members who signed this report joined in an explanatory note (in which this section among others is referred to) which, without seriously weakening the admission, emphasizes the conscientiousness of it.

[1] The United Kingdom, Germany, the United States, and the Latin Union.

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ECONOMIC NOTES REGARDING LUXURY. By A. G. WARNER, Lincoln, Neb.

As national wealth increases it often happens that the spendthrift asks the miser's question, "Shall I not do what I will with mine own?" Numerous answers are given promptly and with emphasis, but they fail to agree with one another. "If the rich did not spend freely the poor would starve," says Montesquieu. "Luxurious expenditure enriches many at the expense of a few," says Voltaire; and he adds, "splendor and pomp are the certain mark of a happy reign: the rich are born for the purpose of spending much." A recent American writer on "Social Equivalents" assures us that "society depends upon and flourishes by the luxurious and extravagant, and even vicious habits and indulgences of its members." On the other hand one might find opinions expressed by a long line of notables from the Hebrew prophets and the Roman Cato down to Emile de Laveleye, which may all be summarized in Goldsmith's apostrophe beginning,

"O Luxury, thou curst by heaven's decree!"

The "apologists" who defend and the "rigorists" who denounce what they call luxury start with different definitions of the term and so manage to justify almost anything they may choose to say, either in commendation or condemnation of it. For instance Laveleye, who says that the "rigorists" are right, makes his position abundantly secure by classing as luxuries only such things as are at once rare, costly and superfluous; and adds that all real luxuries minister to vanity, sensuality or "desire for adornment." More than this he follows Baudrillart in making a distinction between the "desire of adornment" and "love of the beautiful," and so excludes works of art from the domain of luxury. By all these limitations he certainly removes the word very far from the popular conception of it. Only one of the five commodities classed as luxuries in Mulhall's Dictionary of Statistics could be so classed were this definition accepted. Nor does there seem to be any compensating accuracy obtained. When we separate from the "desire of adornment" first "vanity" and then "love of the beautiful," the remainder is much like a globe from which two hemispheres have been subtracted.

On the other hand, the apologists usually define luxury so as to include everything but the barest necessaries of life, and to the term necessary they give a very limited and a very absolute significance. Voltaire urges that if men were restricted to the real necessaries of life they would be reduced,—not merely to the condition of the savage, but to that of the orang-outang. Yet we need not shrink from classing as luxuries everything over and above what is necessary to the life of man; but we must remember that the word necessary is itself a relative, and not an absolute term, and that "the life of man" is more than mere organic existence. A winter trip to the south or a summer trip to the mountains is indispensable to the health and lives of thousands. Subject the inhabitants of a great city to the hardships of a savage life and they would die like sheep in a western snowstorm. Whatever is essential to life as actually developed at a given time in a given place is, within these limits, a necessary of life.

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The significance of the term varies according to times, places, races and individuals.

Senior defines "necessaries" as "those things, the use of which keeps a given individual in the health and strength essential to his going through his habitual occupations." This is well put for our present purposes, if only we can make the words "health" and "strength" apply to the mental and the moral man as well as to the physical; for in studying such a subject as luxury it is preëminently useless to ignore all of man except the animal. In the maintenance of the standard of life which a majority of our people have reached, a certain amount of education is not only a "decency" but an essential. Thus broadly interpreting a broad definition of the word "necessary" we find it possible to define luxury as the supernecessary, the non-essential, the superfluous things—material or other, that contribute to the satisfaction of human wants.

What Bonamy Price calls "progressive desire" is the motive power in man's advancement. Savage and barbarous peoples change slowly because they have few wants, and when these are satisfied they settle into stolid indifference. In opening trade with savages it is often necessary to give them the beads, nails, knives, etc., until the desire for such things has developed, and they are willing to purchase. There is an inertia of opinion and habit which often leads people, savages and others, to believe that whatever is new is bad. Yet probably few of those who still join the diminishing chorus that chants the praises of "the good old times" ("all times when old are good"), would care to dispense with table-forks. Nevertheless historians of an earlier date assure us that an eminent Venetian lady was afflicted by Providence with a loathsome disease because she ventured to indulge in such a luxury instead of eating with her fingers. There are said to have been in the whole domain of Charlemagne no articles of linen except two bed-sheets, a table-cloth, and a pocket-handkerchief. In the sixteenth century it frequently happened that a princess made a present to a prince of a single shirt. In the time of Henry IV of France sugar was sold at the apothecaries by the ounce. In making up her tax-list England formerly classed soap as a luxury but now ranks it as a necessity; not only was cleanliness formerly uncommon in Europe but there was organized opposition to it. To the inhabitants of feudal Europe the ability to read and write was a luxury, and as such usually despised; but to the maintenance of the standard of life now reached it is an absolute necessity. Pure air would even now be a luxury to the inhabitants of our city slums, but after they had enjoyed it for a time, it would become an essential element of a better standard of living.

As already intimated, this continual burgeoning of new desires is not only inevitable but desirable. Senior estimates that if the people of Europe were content with the bare necessaries of physical existence that country could support a population of perhaps eight hundred millions; but it would be a population preëminently fitted to suffer much and accomplish little. Europe would simply be overstocked with digestive apparatus—"the more the worse."

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Misery is a bad motor for keeping up the economic activities of the race. Rewards stimulate more healthfully than punishments; the industrial freeman works better than the industrial slave. It seems quite certain that Humboldt was wrong when he said that the only way to make the Mexicans more industrious was to cut down their banana trees. On this point Say wisely observes that, "were nakedness a sufficient motive of exertion, the savage would be the most diligent and laborious, for he is the nearest to nakedness of his species. Yet his indolence is equally notorious and incurable. It is observable throughout Europe, that the laziest nations are those most nearly approaching to the savage state; a mechanic in good circumstances at London or Paris, will execute twice as much work in a given time, as the rude mechanic of a poor district. Wants multiply as fast as they are satisfied; a man who has a jacket is for having a coat; and when he has his coat he must have a great-coat too. If he has two shirts he soon wants a dozen, for the comforts of a more frequent change of linen; whereas if he has none at all he never feels the want of it."

Two considerations are urged by the "apologists" tending to show that personal desire should be wholly unrestrained in matters of indulgence. The first is that to limit indulgence is to check progress, and the second is that even wasteful extravagance prevents "over-production," and "creates a demand for labor." This second argument embodies an economic fallacy so often exposed that we need do no more than notice it here. Only when we can believe that a sensible Robinson Crusoe would throw away one umbrella in order to "create a demand for labor" in the making of another, can we believe that a community may profitably consume for the sole purpose of giving a chance for renewed production, or that wastefulness finally benefits anyone. The argument for unrestrained luxuriousness first given is also fallacious. Because all advancement results from the development of new desires, it does not follow that all new desires promote progress, or that all that promote it promote it equally.

Economists have heretofore dwelt chiefly upon the different economic effects that follow "productive" and "unproductive" consumption. But even when the decision is to be made merely between two forms of what is called "unproductive consumption," the present writer believes that the economist ought still to have a word to say, and that the "apologists" are wrong in leaving everything to inclination. Suppose it is a question of properly educating one's children, or of keeping and training race horses. In the one case wealth is consumed in the maintenance of professors and tutors, and in the other of jockeys, "sports" and stable boys. "Some years since it was found that the expenditure for the maintenance of the royal stables exceeded the entire sum set apart for public education in Great Britain." If a laborer has made up his mind to spend ten dollars unproductively it is still a question of importance to industrial society, as well as to him and his, whether he will spend it in a wild debauch or in a health-giving excursion for himself and family. Even from an economic standpoint consumption does not end all; even the "economic man" is something more than a bottomless contribution box.

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We have already acknowledged that the "apologists" are right in asserting that progressive desire is the motive power in man's advancement. But it is also our duty to acknowledge with the "rigorists" that it is dangerously easy to advance—down hill. There is one form of luxury that is constructive in its influence on character, helping those whom it influences to a higher and more useful life; but there is also a luxury that is at once wasteful and corruptive. The simplest and most obvious classification of luxuries is into these two classes: those that are helpful and those that are harmful. These two kinds of luxury operate by a common method but towards opposite results; one is an important factor in civilization, the other an important factor in degeneracy. Roscher is right in saying that "an economist who should presume to condemn luxury as a whole would resemble a doctor who should pronounce against nerves in general." Baudrillart says that "the luxury of a healthy society will be healthy, while that of a corrupt society will be corrupt;" and the writer first quoted wisely adds that "diseased luxury is disease engendering."

It is not an easy task to gauge the different kinds of consumption by the standard of human welfare,—that is to sort concrete luxuries according to the classification indicated. Perhaps the very difficulty of the task is the main reason why it has been so long and so unfortunately neglected. The excuse often urged for the scientific neglect of the matter is that the question is a personal rather than a social one; it is said that the only proper guide as to what is right in matters of indulgence must be the instinctive suggestions of each individual's conscience. But it is the duty of science to supplement our instincts and to give them a rational basis. The thoughtless poor agree with the thoughtless rich in believing in the industrial beneficence of extravagance, and their consciences order themselves accordingly. Economics shows their error, and if it can map still other reliable paths through the devious ways of conduct it is a work of immediate and practical importance.

(1) It is characteristic of nearly all helpful luxuries that they are capable of becoming necessaries of life in some higher standard of living, and in default of more definite guide it is often of use to ask regarding any given luxury whether this is true concerning it. Take tobacco, for instance. I suppose it to be true that the more indispensable it becomes to a man, otherwise healthy, the more it injures him. It can thus never become a necessary of life at all, for the simple reason that one's life may at any time become fuller and more complete by merely refraining from the use of it. The tobacco bill of the United States amounts to about $200,000,000—a large contribution to our expenses for harmful luxuries. Of all luxuries essentially vicious it can be said at once that they must always lower the standard of any life they influence. A careful canvass of an American city of 380,000 inhabitants showed that about 20,000 of its people live upon the "earnings" of saloons, brothels or gambling dens. This means that one-twentieth of the available labor power of the city is engaged in undermining its own strength and that of the community.

(2) Lavelaye proposes the following test for determining rightfulness of indulging in a given luxury: Let the consumer ask himself, "Would I,

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for the sake of enjoying it, perform the labor that its production costs?" Few, for instance, would wear expensive lace if required to make it themselves. It is frequently suggestive to ask one's self this question, but the test indicated, if applied with any rigidity, has two palpable defects; the first is that it includes in the tale of permissible luxuries things that belong there by no manner of means, and, secondly, it excludes some things that ought properly to be included. It would afford no safeguard against a man's choosing to waste his own labor on that which is profitless. The Indian who trades the proceeds of a winter's trapping for glass beads and red calico, or the laboring man who exchanges his wages for poor whiskey, appreciates most fully the cost of that which he consumes; the thing which he refuses to recognize is its worthlessness. The stock writers on the subject tell of an Italian nobleman who endured all sorts of secret privations in order to keep his box at the opera; and it would not be difficult to give parallel cases nearer home. On the other hand it would be wrong to compel each person to exchange as much labor-time for each article of consumption as it had cost to produce it, because that would gauge the reward of one's own work by the standard of some other man's efficiency. The brain of a great railroad financier, employed (honestly) for a given time, may be worth to industry a thousand times as much as the muscles of a coal heaver employed for the same length of time. All personal indulgence ought not to be reduced to a dead level of equality, and progress thwarted.

In practice, however, this test would be sufficiently well applied could we but insure a just distribution of the products of human labor. It is the universal testimony that a fair distribution of the national resources is the best antidote a nation can find for the poison of corruptive luxury. It is the failure to apply the rule, "if a man will not work neither shall he eat," to the upper, or better to the privileged classes, that has resulted in the most useless and debasing extravagance the world has known. If unearned bread pauperizes the poor, it is no less certain that unearned luxuries debauch and destroy the rich. The most popular labor paper of the present day publishes each week a column of "Society Notes" made of clippings from current periodicals giving two classes of incidents, one illustrating the most pampered and effeminate luxury of our time, the other the abjectest destitution to be found in our great cities. The column reads like a page from the caustic satirists of Rome, contrasting the misery of the provincials with the excessive and vicious indulgences of the Roman dudes; or like a chapter from Arthur Young's travels in France during the closing years of the Ancient Régime. The implication is that, as the privileged classes of Rome exploited the provincials, and the nobility of France the peasantry, so the wealthy classes of our own time are exploiting the laborer; and in so far as this is true it must tend in the modern, as in the older instances, to the increase, not of constructive but of corruptive luxuries. The luxury that springs from wealth unjustly got is twice cursed: cursing the rich whom it corrupts, and the poor whom it impoverishes and enrages.

(3) When we pass from mere suggestion and go behind the market re-

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ports to estimate the worth of economic goods in terms of man's welfare, the difficulties are many. Some economists dogmatically insist that they have no right to push their investigations into this field. They hold that the purpose for which economic goods exist is to satisfy human wants, and if this object is attained no further questions should be asked. Yet surely one may properly ask whether, from an economic standpoint, it is well that a given desire should be gratified. If the economists will not try to answer such a question some one else ought to do so. But there is every indication that the economists will not, as a class, shirk their responsibilities in the matter. The "dynamics of consumption" will not be forever neglected.

Suppose one desires to learn the economic significance of the annual consumption of $700,000,000 worth of alcoholic beverages by the people of this country. The conclusions of physiological chemistry must first be noted. Next, the special influence of our climate upon mind and body must be reckoned with. Thirdly, a large number of individual cases must be studied and tabulated in order to determine the exact effect of the drink habit upon "individual economies," as the Germans call them. The budgets of family expenses, collected by the French, German and Belgian statisticians, and latterly by our own labor bureaus, are here available. Fourthly, industrial society may be studied by classes. In some of these it is found that drinking is a consequence rather than a cause of bad conditions. For instance the Buffalo grain shovellers who "trim to the elevator's foot" work under conditions that make the use of artificial stimulants almost indispensable. On the other hand, in many of the better conditioned trades nearly all the acute evils that the workmen suffer, and nearly all the economic wastage that is found seems to come from the abuse of stimulants. Fifthly, we may study the human wreckage of the time, and trace backwards as carefully as we may, the sources of crime and pauperism. A careful analysis of several thousand cases by American Charity Organization Societies gives intemperance as the chief cause of destitution in only about fourteen per cent. of the cases. Dugdale, in studying the "Jukes, "a family of confirmed paupers, finds intemperance a lesser cause of poverty among them than sexual licentiousness. Sixthly and lastly, we may glean some important conclusions from the study of national statistics. Roscher states that when temperance work had been successfully prosecuted in Ireland for a time the annual consumption of brandy fell from twelve to five million gallons. The government revenue from the tax on this article decreased £750,000, but at the same time the production of other taxable articles increased so greatly that the aggregate revenue derived from the country was £91,000 greater than before. Facts of similar tenor are given for some of our states where prohibition has been measurably enforced. From these and similar sources must be gleaned the facts that may at last enable us to determine with scientific accuracy how great a negative factor in our national economy is our national liquor bill.

The laboring population of Glasgow is said to have consumed during later years continually decreasing amounts of milk and oatmeal, and con-

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tinually increasing amounts of tea and sugar. The result is believed to be a distinct physical deterioration, one symptom of which is a serious increase in the number of "rickety" children,—those whose legs are too weak to support them. Probably there are other causes contributing to the effect observed, but at any rate the problem indicated is typical of thousands that await solution. Without doubt they belong first to vital science, but their economic bearings also demand study. The recognized agents of production are land, labor, and capital. Man has been less studied as an economic factor than either land or capital. The American economist who has given the most attention to the subject of the consumption of wealth assumes that man is a stationary being; that economic conditions change, but that man is changeless. This is to ignore the most important fact connected with economic consumption. What the man of to-day consumes goes far towards determining what the man of the future is to be; and as his standard of living varies, his influence as an economic factor varies also. The luxuries of to-day become the necessaries of to-morrow, and they deserve at the hands of economists more careful consideration than they have yet received.

THE SCIENTIFIC APPLICATION OF HEAT FOR COOKING FOOD. By EDWARD ATKINSON, Boston, Mass.

[ABSTRACT.]

AT the meeting of this Association held a few years since at Ann Arbor, I submitted a paper as Chairman of the Section, on Science applied to the Consumption of Food. In that paper I treated mainly the statistics of food; in the Supplement I gave the most valuable portion of the communication in the form of various tables prepared for me by Professor Atwater, giving what may be called Dietaries or Days' Rations of different kinds of food, sorted with the respect to the right proportions of the nutrients contained therein, and at various prices for a day's ration. Through this statistical investigation, I have been led to consider the waste of food material through the lack of any true science of cooking. The position then taken as to the relative cost of subsistence or food, as compared to the other necessaries of life, clothing, shelter and the like, has been fully sustained by subsequent investigation on the part of the various Bureaus of Statistics throughout the country. With respect to by far the greater part of the population, probably at least ninety per cent, the cost of the food material, whatever it may be, represents one-half the income of the family. As the income becomes less than the average, the relative proportion of the cost of food material becomes greater. The variation in the price of an adequate day's ration, which I have been able to determine, ranges from about ten cents a day (at which I have ascertained that some poor students caring for themselves have succeeded in maintaining themselves in a fair condition of health, living chiefly upon oat-

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meal) up to about one dollar per day expended per inmate, including servants, in a first-class city hotel; the actual expenditure per guest being two dollars each. The average cost of food material per capita fairly corresponds to the sum at which I computed it in my previous address, making allowance for the reduction in prices since that day; viz., somewhere between twenty and twenty-five cents per adult for each day's portion. The lowest terms on which large numbers of persons are subsisted according to their own standard of comfort may, I think, be found in some of the larger factory cities of New England, where meals are furnished to operatives known as "mealers," being those who do not live in the factory tenements but at some distance from the factory and who take their meals in the factory boarding-houses; these mealers are now furnished with twenty-one meals per week at a cost to them of $1.60, and at that price the purveyors make a profit. Yet even on this average of the cost of subsistence computed at twenty to twenty-five cents per day omitting the very lowest, there is a great waste which I think may be attributed to the want of any true science in the application of the art which lies at the very foundation of cooking; to wit, *the application of heat to the process of converting crude or raw material into a suitable and appetizing form for nutrition and digestion.* On the whole, it may be said that the whole practice of the art of cooking in this country is distinctly wrong, tending to destroy both the appetizing and the nutritious quality of the materials which are used in greater or less measure, and to promote dyspepsia to the utmost. The wrong direction is due to the attempt to cook almost everything quickly. The stoves, whether coal or oil, which sell most freely and readily are those which can be recommended to do their work in the quickest way and that is generally the wrong way. On the other hand, the very art of fine cooking and the skill of the skilful cook consists in the application of heat at the right degree and for a suitable time, according to the kind and quality of the food which is to be converted.

Without claiming any but the merest superficial knowledge of chemistry, nutrition and physiology, I venture to present the subject.

From my own experience I have reached the conclusion that the flavor which is desired in many kinds of food is an actual *product* (if we may use the word) developed in the process of preparing the material by the application of heat. For instance, if we grind the green coffee berry and attempt to make an infusion from it, it utterly fails in producing what we call coffee; if the coffee berry is burned in place of being browned or roasted by heat, and the infusion is then made, it is acrid, unpleasant and probably injurious; again it is not coffee in any true sense. But if the right degree of heat be applied for the right period of time so as to produce a uniform result, the coffee then being ground and the infusion made, we have true coffee. Unquestionably this flavor of coffee is developed by the chemical change worked by the action of heat. I find the same treatment to hold with respect to the treatment of grain, of fish and of meat.

Raw meat is unpleasant to the taste or flavorless; when baked in the common way in stove or range at a high heat (the precise degree of which

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is almost unknown) it fails to attain its true flavor, gives off offensive smells, and becomes in part indigestible by the "cracking" or change which is effected in animal fat at a high heat; but if meats are cooked slowly at a degree of heat below that which cracks or dissociates that portion of the animal juices or fats which is volatile at a high heat, the flavor is fully developed as well as the nutritious properties; no offensive smell is given off in the process and when such meat is re-heated it has not the unpleasant tang or greasy taste which is developed in meat cooked at a high heat, when heated over again.

The flavor of fish is yet more fully developed by cooking at a moderate degree of heat, less than that at which the fat or juice of the fish is dissociated or distilled.

With respect to bread, the contrast is as great or greater; if bread is subjected to a high heat, being composed almost exclusively of starchy or carbonaceous material, the crust is almost immediately formed; this crust becomes a non-conductor of heat, and if the bread is subjected to this high heat long enough to cook the middle of the loaf thoroughly the crust is burned. Every one is familiar with the ordinary condition of badly-cooked bread, the middle being indigestible; the yeast plant not being killed goes on fermenting; the nutritious properties are not fully developed; and when kept the bread dries up quickly or molds as readily, according to the condition of the atmosphere.

I find that if I subject bread to a heat not exceeding 250° to 300° F. for twice the usual time, a tender crust is formed while at the same time the bread is cooked to the very heart of the loaf. It has a finer flavor than the ordinary bread, and may be kept for a week under ordinary conditions of the atmosphere without drying up or becoming mouldy.

The missing science would therefore seem to be the right method of applying heat to the conversion of food material into digestible and nutritious food.

The first rule in the development of this science, or in the art of cooking, must therefore be *to catch your heat*, to put it into the oven, and to retain it at a normal or given degree of heat adapted to each kind of food for any length of time. As a matter of course this cannot be accomplished in the ordinary cooking ranges or stoves. Coal or wood cannot be burned under ordinary conditions so as to be readily controlled; a greater or less proportion not only of the unconsumed gases but of the heat generated will go off through the chimney; while the materials of which the common stove is made, permit the heat to escape and to diffuse itself through the room perhaps in very much larger proportion than that which is retained and converted into work upon the food.

The necessity of the case therefore calls:

1. For the perfect combustion of the fuel so that no chimney may be required to carry off the waste products.

2. An oven in which heat may be maintained at any normal degree required for a given number of hours under quick and easy control.

All this has been accomplished in a somewhat crude method in the cook-

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ing vessels which I have named Aladdin Cooker and the Aladdin Oven. I had hoped and intended to be present at the meeting and to perform some experiments, had circumstances not prevented; and I will therefore give a short description of my apparatus.

The Aladdin Cooker is a development of the Norwegian cooking-box, with an attachment thereto, corresponding to the water-back of a cooking range or cooking-stove. The box being made of pine, or of pine slabs filled in with sawdust, about one and one-half inches thick, is lined with metal; from one side project two pipes one above the other. To these pipes a conical heater is attached through which water circulates where it may be subjected to the heat developed from the top of a chimney of a common kerosene lamp; the water may be made to boil by the use of a powerful lamp, or it may be kept for any length of time at about two hundred degrees. Many kinds of meat and of grain can be thoroughly and nutritiously cooked at less than two hundred degrees if subjected to heat for a sufficient length of time. This apparatus has been used by many mechanics who are obliged to get an early breakfast; they can place in porcelain pots portions of meat, fish, oatmeal or corn meal, put them into the cooker, light the lamp, and leave the process of cooking going on through the night. In the morning a nutritious breakfast is found to be ready without any further preparation.

The *Aladdin Oven* consists of a case made of properly prepared wood-pulp framed in a metal lining which constitutes the outer oven. The walls are made from one-half inch to one and one-half inches thick, according to the size of the oven; a round opening is left in the bottom (the bottom being made wholly of metal) through which the heat from the lamp passes. Inside and set off from this outer oven is an inner oven in which the food is placed which is to be cooked. A ventilator is at the top of the oven communicating with the inner oven, but it is seldom necessary to use it.

In this oven, broiling can be imitated in a way which many prefer to the regular method; roasting can be accomplished in perfection; also baking and braising.

The heat must be in proportion to the lamp or lamps placed under the oven. My experience has extended from single pounds of meat or small birds, to sirloins of beef weighing thirty pounds, turkeys and geese weighing seventeen pounds; and so on.

By the use of a lamp of the Rochester type, in which the consumption of oil is perfect, about sixty pounds of food can be thoroughly and nutritiously cooked in four charges, with the use of only one quart to three pints of oil burning from eight to ten hours.

These inventions are crude, but they lead the way toward the right system of building stoves; viz., with non-conducting jackets so as to hold the heat which is imparted by the perfect combustion of the oil or gas which may be used as fuel.

There may be gentlemen present who can bear witness to the appetizing quality of the dishes which I have put before them. I regret exceedingly that I could not be present to give a taste, at least, of the product of my ovens to the members of Section I.

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FOOD MOULDS THE RACE. By Mrs. NELLIE S. KEDZIE, Manhattan, Kansas.

IF Abraham is called the Father of the Faithful, then Sarah, the princess, who took fine meal and prepared food for the three wanderers, is the mother of a princely line of hospitality whose dainty hands have fed angels unawares in all ages.

We speak of men and their deeds and seek to explain their careers by saying "they come of good blood;" but whence comes good blood save from good food, the literally "circulating medium" of life.

The human mind, no less than the body, must grow and develop: while all admit the simple fact that the body is sustained and developed directly by the food eaten, it is as fully conceded that mental growth is dependent upon proper physical nourishment. And no question will arise when it is asserted that neither mental, moral nor physical growth will be full and general unless the food be what is needed as regards quantity, quality and digestibility. Character is moulded by each day's living. Every meal eaten has an effect upon the moral nature as well as the mental and physical.

Animals living upon flesh are those of fierce, eager energy, daring, cruel, masterful, but gloriously successful in living the life of war their physical courage makes possible. The herbivora are peaceful, teachable, tender with each other, but lacking in the courage, ambition and energy characterizing those animals of carnivorous habits. Playfair says this is noticeable in the same species, and asserts that the bears of India and America, living upon mast, are mild and tractable, while those of the polar regions, feeding upon a meat diet, are savage and untamable.

Man eats all food; so we find all traits of character developed. One may counterbalance another. Another may predominate. However much we attribute to heredity, we must concede that food, the building material of the body, will to a great extent determine the structure; and habits, tastes and thoughts are largely the results of bodily cravings. We conclude, then, feed a child properly and he will be the man sought for. To a certain extent, this is true. To how great an extent is yet to be learned.

Many nations of the earth depend each on some staple for diet. Who shall say the Chinaman's rice, the Greenlander's whale blubber, the Sandwich Islander's fruits, or the buffalo meat of the American Indian has not been the source of the traits we find so prominent?

Our own nation stands to-day with its working classes superior to those of any country on the globe. The laborer has better pay, enabling him to live upon better food. The German, the Swede, the Bohemian, who comes to this country and lives upon the food common on American tables, soon shows the difference in diet in his increase of mental and physical ability and endurance. This is especially noticeable in the housework girls and farm laborers. While the increased facility for learning is of some import, the change in food is easily seen. The different climate makes a change in diet necessary if growth be kept up. The climate of the United States, where the clear dry air develops fruits of firm flesh and aromatic

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flavor, gives to its people a more "high-strung" nervous organism, and for this they must have a higher order of food. We find this accomplished by the eating of meat. It is doubtless true that nitrogen is conducive to growth in brain power, and Leibig believes that the rich nitrogenous diet of English-speaking people is the real source of their indomitable energy. The people inhabiting England eat an average of four and one-half ounces of meat per day, while just across the Irish sea only two and one-half ounces per week is the average. What wonder the Irish have grown rebellious, suspicious and lawless? A hungry man is an angry man, and in spite of his ten and one-half pounds of potatoes per day the Irishman gets but little of the element we believe necessary to vital force, for potatoes give only three-tenths of one per cent of nitrogen.

Whether meat is the needed substance, or whether nitrogen can be supplied in some cheaper or better way, is not the only problem to be solved. Cheapness in food may become a great wrong. When food is too cheap, labor becomes cheap in proportion, and the value of life is lessened because so great an amount of human strength may be bought for little money. With the wages of our country, the average American poor man is well enough provided with the money to buy the necessary amount of food. The great want to-day is ability to properly prepare that food so it shall do for him what he needs done. One pound of beef should give one hundred and eighty-four grains of nitrogen; but suppose it be fried in grease until it becomes so tough and hard no digestion can assimilate it? A date is more than half sugar, but if it be not palatable to the eater, it may not digest at all, and a strawberry, though it be eighty-seven per cent water, will give more nourishment than the unassimilated date. Only that portion of the food which is digested and used by the body can be of any value. Food taken into the system, must, in some way, be disposed of, and if of no value it is worse than useless, for it requires force to dispose of it; and this unnecessary expenditure of force, bringing no return, weakens the structure quite as rapidly as honest work which brings full compensation.

There is too little known of the real values of foods, and less is known of them in the different states we find them when cooked well or ill. The chemistry of to-day gives much toward a comparative knowledge of the food value of many substances, but these values are very vague when it comes to the question of practical worth. It is not enough to know that a dish of food contains enough of the requisite elements to give strength for a certain piece of work. If that food be not easily assimilated by the system into which it is taken, or if it require too much vital force to be properly digested, it becomes worthless; or worse, a drain upon vitality.

It is not enough to know that a pound of food ought to give certain growth or strength; the knowledge of the best method of preparing that food in order to obtain from it all the benefit possible is absolutely essential. If all people were simply machines which would digest all foods alike, and if all cooks made all dishes exactly alike, some definite results

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might be obtained. Realizing that the average adult must have 4100 grains of carbon and 190 grains of nitrogen for subsistence diet every day, the next step would be to know just how much carbon and nitrogen will be needed to hoe the garden or sweep the floor, and the calculation for each person's meal may be made on that basis. However absurd such an idea may be, it is only an extreme of what every good house mother does to-day. In planning her three meals, she prepares more meat for the worker, be he of brain or hand. The carbonaceous foods represented by the fats and heavy sweets, she saves for winter use, when the outside cold is to be combatted; while the dainty dishes, made up mostly of cold, do their share toward mitigating the heats of summer.

The selection of food and the preparation of the meals form a science the depth and importance of which are just dawning upon us. The influence exerted in a home may be very materially affected by the food upon the table. The laboring man who has in his home an intelligent wife who prepares the food he needs to nourish his body properly is seldom the man who depends on tobacco for nerve force, and who ends his day over a beer mug. The merchant prince whose dinner is ordered with thought for his work, for his physical and mental needs, is seldom the man who lingers over his winecup, or who goes to the gaming table. A well-fed man is a contented man, and plenty of the right kind of food is one of the potent forces against all crime.

Crime of many kinds is urged upon members of an enfeebled race by bodily cravings which years of proper food would do much toward removing. So much strength has been wasted in attempting to utilize food of insufficient nutrition, or food which is not easily digested, that the system, being thrown out of its normal state, is unfit for healthy work and thought. Many of the grave questions of the day would dwindle into insignificance if every woman in every home knew how to best prepare the food her husband earns so that it would give to him the kind of strength needed for his work. If the table be rightly managed, the several appetites, as well as the several kinds of work, must have consideration. "What is one man's meat is another man's poison," and earnest study, faithful thought, and careful judgment are demanded of the woman who is a success in her home.

A nation is made up of homes. The homes make the men who are the nation. The manager of the household is the one upon whom depends, to a great extent, the strength of mind and body developed in that home.

Knowing this as we do, it seems strange that in the plan for the education of our girls we have neglected to prepare them for the one position in life which they are almost certain at some time to be called upon to fill. Every woman, be she rich or poor, mistress or maid, has need to know what to cook, and how it should be cooked to bring desired results. While every housekeeper takes some thought for the needs of her household, she takes that thought with true discretion, only after years of experience. When our first parents left the garden for the homestead in the country, we are told, "The world was all before them, where to choose their place

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of rest, and Providence their guide." All the ages since, when the inexperienced bride enters her Paradise of wedded life, though she has a great world of cookery before her, she has sore need of a Providence to guide her choosing, if her husband escape dyspepsia, and her happiness be complete. There seems very little in the way of helps for a young housekeeper. She must learn to feed her family by hard experience. As our nation proves its strength to-day, all honor to the women of the land who have so well learned to make bricks without straw!

The larger half of humanity eat too much and digest too little. The greater part of the food on American tables is only in part the food it might be, because of inferior preparation. When one of the essential studies in all schools is on the selection of foods, and when all our women are taught the proper preparation of foods, then we may look for radical change in the condition of the poorer homes of the country.

A girl needs to be taught carefully and thoroughly for her life work, and there is no way by which the art of cooking may be taught except by actual experience. No one can learn this art from books. As well think of sending out an accomplished piano player by giving her plenty of well-written music books! No amount of talk can tell one just how long to knead bread to always arrive at the same result. No amount of experiment can give an exact rule for amounts, or weights, or heat, or time, in order to reach precisely the same end. Conditions are so varied that while general principles can always be depended upon, much judgment and some practice must be elements of every dish compounded, or sometimes, a dismal failure will be the result of the cook's efforts.

Every girl has a right to some preparation for her future years! Every teacher needs to implant in every child's mind the thought of the importance of knowledge in the selection of foods, their values as regards strength-producing elements and digestibility. The individual taste as well as the individual needs, must be consulted in this selection.

We are doing something toward giving our women some of their rights in this direction. Whether it is to be wise to bring cooking into the public schools and teach it as certainly as we teach grammar, is an open question. The one study is surely as important as the other! Or whether special schools for teaching the art will be the future rule, time alone can tell. Practical cooking must be taught, and the women of the land must learn to cook wisely and well!

Whether the preparation of food in the future shall be done in the individual homes as it is done to-day, or whether it will be managed on some coöperative plan, it will still be essential that the person who carries the responsibility of the food shall know what is to be cooked, how it is to be cooked, when it is to be eaten, and by whom. Then results will be known, planned for, and attained. Then will our nation be truly blest, for her women will look well to the ways of their households, and "their children will rise up and call them blessed!"

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HOW SHALL WE PROTECT OUR FORESTS? By R. W. PHIPPS, Toronto, Ontario Forestry Commissioner.

IN answer to the question, I will mention the different methods which appear to me most feasible.

Arousing public opinion.—Each State or Province should employ a competent official to obtain information on the subject, and circulate it by means of pamphlets generally called Forestry Reports. With these, two things are advisable; first, that they be written in an interesting style, for mere dictionary statements on the subject would simply be left unread; next, that they be widely distributed, and among proper persons, not merely sent to officials and prominent men, on whose shelves they are likely to remain untouched. An excellent method is that of obtaining, from some well-informed person in each locality, the names of all he knows likely to read with profit such a book, and sending one by post to each on his list. In addition to this, it will greatly aid if the forestry official be able to address, during each year, many communications to the press throughout his State or Province. In addition again, addresses delivered at many points each year will be found of great service.

Free distribution of trees.—Young saplings, obtained in the forest, are very inferior to nursery-grown plants. The forest-sapling has generally two or three long roots, which cannot be obtained in full extension, or carried or planted if they were. They must be cut, and the chance of growing risked. Then, many of them are grown in the shade, and will not stand the open sun. On the other hand, the nursery sapling, two or three times transplanted as it should be, gets a more bunchy and fibrous root each time, and naturally grows far better when placed in its ultimate position. Very small trees, especially evergreens, can be, indeed, and often are, taken from the forest, and planted in the nursery, when, after two transplantings, they have excellent roots. But when obtained from seed, or when young from large nurseries, the work is far more easy and certain. When one goes for trees to the bush, though saplings apparently be countless, it is surprising what trouble it will take to find what is wanted, and to get fair roots then. Again, in our settled country, where cattle are often made so free of the bush, young trees are hard to get in any case. For all these reasons, if the farmer had available, when he was ready, some thousands of good, well-rooted, healthy saplings of the kind he wishes, he would often be willing to plant and care for them. Therefore, I consider that a large public nursery, where trees might be obtained free of cost, would be one of the greatest inducements to landowners to plant. It will not do to say that he who wants trees should buy them. There is an inducement needed here, or the work will not be done. The work is national; it is the nation desires the farmer to plant the trees; it was the fault of the nation that he was ever allowed to

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obtain public land at first without an agreement to retain a certain portion in trees. I have now, for seven years, been examining this subject, and I am strongly of the opinion that under a system of free saplings twenty times as much planting would be done as at present. Instead of free nurseries, governments sometimes give grants of orders on nurserymen. With careful and earnest supervision, either plan would answer. The great point is—free distribution of young trees.

Settling fresh woodland.—The great error of the original settlers was taking hill and hollow, mountain and valley, indiscriminately, for settlement. The result is that many mountain tops were cleared, farmed, and ruined, for the soil washes away, and in a few years nothing remains but to desert it, and go elsewhere. That the mountain should be wooded and the sloping valley cropped is the very A B C of forestry, and this should be secured by saying to the settler, "You cannot have such a lot; it is a mountain top; it must stay in wood; and if you take such a lot, you must agree to keep such a part in wood, and to keep cattle out." This may seem harsh to the settler; but in the end it would be far better for him. If there is one lesson more than another which over-clearing has taught America, it is that people should not be allowed to enter the woodland to hack and hew as they please. There are now millions of acres of deserted and worn-out farms, in the Eastern States and Canada, which were simply the elevated ridges fit, with care, to bear timber for ever, but not fit for farms, as the earth washes off. It is hard for the settler in a forest to know the elevation, but the survey should have regulated matters. I wish it to be understood that here I speak from my own experience; when over thirty years ago, with no one to guide us, many of us entered the forest, we cleared much land that never should have felt the axe, and is now worthless, or very near it. This is not proposed in the case of the ordinary rolling land of the country, nor where there are a number of small hills. But where thousands of acres form the watershed of a mountain range, they should remain in wood.

Forest reservations.—Forest reservations, of twenty or thirty miles square, should be left at those places, found in most countries, where the sources of many streams arise, that the rivers, which pass thence through the rest of the country, may be preserved. These will form reserves, where timber may grow, to be thinned, not cleared, at maturity; they will also give shelter where birds and animals, otherwise in danger of extirpation, may still live; and, as the country around is cleared, they will be invaluable for summer resorts. These would, if cared for, remain beautiful remembrances of the pristine forest, full of sylvan glades and delightful groves, retaining the undergrowth, the wild flowers, the deep leaf bed, the pleasant freshness of the virgin forest. In this state they are most valuable preservers and distributers of moisture. But if left without care, fire will here and there burn the hills to the barren clay, cattle will destroy the undergrowth, and the whole scenery appear dry and desolate, compared with what it was, and might still have been. Two

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things, then, are here necessary: prevent settlement there, and appoint care-takers.

Remission of taxes on woodland.—It would greatly assist in preserving a considerable amount of forest throughout the country, if taxes on woodland, where the country is sufficiently cleared, were in all cases remitted, and if, in the same connection, some stipulation were made that cattle should, to a proper extent, be excluded, very great benefits would follow. For it may be here remarked that a wood dried up and hardened — its undergrowth destroyed by cattle — is of very little value climatically, compared with one where the forest bed is preserved. Neither will it remain a store of fuel, for, there being no young trees, the forest must ultimately die. There is no doubt, however, that many of these wood lots are allowed to decay, because it is intended to clear them up, and that, if the remission of taxes induced the owners — as it in most cases would — to keep them as permanent forest, much better care would be taken of them.

Tree claims.—In prairie countries, sections of land have been given free to settlers, on condition that a certain number of acres, generally ten, were planted with trees, and kept in good condition for a certain period. This has been tried for years in the States, but many frauds are said to be perpetrated under it. I have myself found, when at the great private nurseries in the west, where the young trees were procured, that it was always a practice to purchase the worst—the culls, in fact, for tree claim lots. The system was nevertheless valuable, but needs to be carried out in good faith, by competent and firm inspectors. The prairie lands, both of Canada and the States, urgently need tree planting, and will give good returns. Plantations of miles square have been grown these eight years in Kansas by railroad companies, and with good paying results. Yet, even with this successful example before their eyes, settlers plant little. When I saw them they were four and six years old, yet still the prairie for hundreds of miles was comparatively treeless, though all admitted the benefits of trees. I should recommend, in prairie countries, while the soil is yet in government hands, that many millions of young trees be planted and cared for under government appropriations, cultivated to keep down weeds for a couple of years, and the prairie close by ploughed to prevent fire running to the trees. In this we should not wait for experiments long. It is necessary to plant four times as many trees as needed, to allow for thinning, and by planting different varieties, it would be easy so to arrange them that even if three-fourths failed, we should still have a forest. But three-fourths would not fail. This would cost millions of dollars, it is true, and it is equally true that it is a matter in which, above all others, millions should be spent. If, when I first saw the prairie States, between thirty and forty years ago, an appropriation of ten millions of dollars had been given to plant trees and care for the groves then existing, these States would, I am well assured, be more valuable by a thousand millions of dollars now. Can nations not afford such

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sums? Let us think of the sums they are without exception ready to spend in war, and then answer. But that, it may be said, is to preserve national life. So is the other. Every well-informed student of history is aware that in all the past, as the forests of a country were destroyed beyond a proper proportion, national life weakened, and by the time when, as examples show us, the treeless desert had overspread the ground, the nation was dead.

Preserving timber forests. — The preservation of these has been little thought of in America, and the lumberman, on condition of paying the authorities a certain amount, has been too often allowed to cut at his pleasure. No care has been taken to replant forests. In Europe, on the other hand, the wood-buyer is carefully instructed as to what portion he may clear or thin, while, as soon as the ground is ready, it is again planted, or the gaps filled. Two reasons for the American practice existed: first, farm land was needed. This reason is not now valid, as the pine land now left is very largely too poor for agriculture. Second, and chiefly, the timber could be sold. Matters have now come to pretty much the following condition. This generation, say for thirty years, will have timber enough, though they will have to use much wood hitherto thought unfit. After that, there will be little good pine and not much good hardwood in our present forests; what is obtained will be brought from British Columbia and the forests of the Southern States, while the generation following will exhaust these. Considering the well-known benefit of keeping a large section of the country in forest—benefits which it is not the province of this paper to state—I would earnestly urge the people of America to consider how much more advantageous it would be at once and decidedly to say of certain large portions now in forest, "These shall not be cleared for settlement—these shall be sacred to the tree." Once this determination is arrived at, the rest is easy. Nothing is more simple than to introduce and maintain a method of forest preservation, if populations demand it, and governments fulfil their desires.

It is often said, "We have a large proportion of forest land." But most of this is not good forest. Much has been overrun by fire, much culled of every good stick by the lumberman. But nearly all of this might be renewed, and made good, permanent forest, if the means were used.

Means used in Ontario.—I will close this paper by stating what is done in Ontario for forest preservation. Much forestry literature has been for years circulated by the local government, and with good effect. A money bonus, half paid by government and half by the township, is given for the planting of lines of trees, in good condition after three years, in every township which chooses to adopt the law. Over fifty rangers, half paid by government and half by the lumbermen, are kept in the woods during the summer months to prevent fires—a very valuable measure. An Arbor Day is also yearly held, with excellent results.

Finally, the answer to the question, "How shall we protect our forests?" is "Spend more money in their preservation, and be less eager to make money by cutting them down."

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CERTAIN ASPECTS OF AGRICULTURE IN THE ARID REGIONS. By J. RICHARDS DODGE, Washington, D. C.

[ABSTRACT.]

THE soils of the arid region are generally fertile to excess. Depletion of valuable elements, rather than accretion, tends to their improvement. Humus is comparatively deficient, but carbonaceous matter can readily be supplied by the roots and stalks of rankly growing plants. Thus their amelioration is practically dependent upon one contingency, requiring only the application of water, with mechanical disintegration by suitable methods for reduction to necessary tilth, and the chemical changes which occur naturally in the cultivation and growth of plants.

The great plains which constitute the eastern slope of the Rocky mountains are not level, as they decline eastward from four to five thousand feet in five hundred miles, or eight to ten feet per mile, a scarcely perceptible slope, especially in comparison with the minor undulations of the surface, the "divides" between the streams and valleys which collect the superficial drainage waters, the "draws" which carry the storm waters to the creeks and rivers, and something of the irregularity which obtains in more eastern regions sometimes designated as rolling prairie.

A large proportion of the soil of these plains, which appears on the surface to be gravel from the loss of its finer particles by the perpetual winnowing of the winds, exhibits a marvellous transformation when inverted by the plough, a rich brown or other dark color, breaking readily into fine tilth, easy of cultivation after the first breaking, which requires two pairs of good horses for thorough subsoiling. The sturdy homesteaders, who understand the advantages of thorough cultivation, while laboring under a scarcity of teams, increase their power by supplementing a pair of horses with oxen, even training cows to the service when necessary.

These plains, seen in the day of the Indian and the buffalo, burning in the glare of the noonday sun, brown and sere with a scanty covering of drying grasses, flecked with prickly patches of cactus green, present a strange but not disagreeable contrast with fields now seen by thousands, golden with the ripening grain, purple with a sea of waving blossoms of the alfalfa, or green with the leafy vines of the potato which hide from view the first glimpse of the brown soil which they shade and cool and moisten. And yet a single year suffices to change the desert to a garden.

The magic word which effects a change so sudden is *water*. This is the only essential element that is deficient and to be economized. It is available, first, in the precipitation of rain and snow; second, by irrigation from waters at present obtained through the aid of engineering and the use of capital usually impracticable by a single farmer; third, by waters to be collected by storage reservoirs in the higher elevations; fourth, by catch basins throughout the entire plains area for saving the surplus storm water; fifth, by pumping from the underground channels beneath the bed of the streams which are nearly or entirely dry on the surface; sixth, by the expensive and restricted (if not uncertain) means of artesian wells.

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These methods are all in successful operation except the proposed reservoir system to be undertaken by the government, though the artesian plan has a very restricted operation, while its extension is active at present. Several millions of acres are already reclaimed, or rendered more productive by the application of water. In Wyoming, water has been taken from about four hundred water courses, through more than two thousand ditches, irrigating a million and a half of acres. Colorado is able to make a still larger showing, with results in agricultural production that are claimed to surpass in value the output of mineral wealth of that prosperous state. California, by the aid of irrigation, long since placed her agricultural products at the front of her magnificent display of wealth in annual production. Montana, Idaho and Utah are advancing in improvement with great rapidity, through the distribution of their stores of running water. Arizona, Idaho and New Mexico have less abundant resources developed in a less degree.

In the application of water there is much waste, in the seepage of canals, and in passage through soil and subsoil of much of the water applied to the fields. This surplus finds its way to the stream from which it came, and can be drawn out a second time by new irrigation works at a lower level. This has been done notably on the South Platte, in the vicinity of Fort Morgan, where thousands of acres are under irrigation, with an abundant supply of water, though the South Platte, above Denver, and Cache le Poudre, above Greeley, have been drained nearly dry to refresh the multitude of farms and gardens of those higher levels.

It has been suggested that the quantity of water required would become less and less, after modification of the soil by long cultivation. Though the first saturation of the soil requires an amount of water which is not necessary for the second, and its hygroscopic condition is greatly improved by repeated applications, the current experience in irrigation does not exhibit a continuous reduction of the supply to the vanishing point, so that practically a limit of the "duty" of water prevents the annual enlargement of the irrigable area. In ordinary usage the application is not frequent enough to keep the soil so moist as to lessen materially its capacity for moisture.

After all available water has been obtained, by these various means and expedients, there is still a large part of the superficial area that must remain unirrigated, possibly five-sixths, probably not more than nine-tenths of the northern and central portions of the arid region, while in the southern the proportion may reach nineteen-twentieths. In the entire breadth of the territory designated as arid it is probable that all available waters will scarcely suffice to reclaim and fertilize one-tenth of the whole.

Yet the remainder will not be quite a desert. There are what are agriculturally designated rain belts, where sixteen to eighteen inches of water, sometimes twenty inches per annum, are found to produce good crops of corn up to an elevation of 3000 to 4000 feet, and wheat, oats, potatoes, alfalfa and many grasses up to 6000 and 7000 feet, by adaptation of methods of culture to the best utilization of available moisture.

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Thirty years ago half of Kansas and Nebraska was believed to be hopelessly arid, useless for purposes of agriculture, though of some value for its scanty pasturage. It was so reported by hunters and explorers, men of business and men of science as well. Their view was superficial, their data for generalization incomplete; agricultural meteorology was then in its infancy, as indeed it has not yet arrived at its years of mature discretion. There are evidently yet powers and principles that are not dreamed of in its philosophy. The one hundredth meridian, then assumed to be the limit of profitable agriculture, has become the centre of one of the finest corn belts within the national area.

The extension of homestead entry and settlement has gone on beyond this imaginary line, without regard to the dictum of the practical sense or science of former days, breaking prairie, planting crops and growing timber. It has pushed its way westward, driving the cattle of the range before it, sinking wells, building houses and barns, on through county after county, and stopping not at another barrier, the imaginary line separating those states from the great mountain desert area of Colorado. Here the elevation has risen to 3000 feet or more. Still there is a rainfall of about fifteen inches, and the adventurous settler dares to file upon the lands of eastern Colorado for purposes of settlement and cultivation under the homestead law. Now the enterprising people of the Centennial state are claiming the existence of a rain belt in Colorado, and her most intelligent publicists are claiming, for the rain belt production in agriculture in 1889, one-third of the value of all the agricultural products of the state.

Thousands of new farms are annually taken up in this belt, which is held to include all the eastern counties, from north to south. It also includes the grand divide between the South Platte and the Arkansas, a ridge stretching eastward from the mountains, from an elevation of 7000 feet which gradually falls off towards the east, as it does more precipitately towards the north and south.

The still higher mountain parks, while liable to frosts, and therefore useless for a wide range of agriculture, are valuable for hay production, and capable of producing oats and potatoes on their lower levels.

Most of the homesteads of the "rain belt" have been established within three years, and are promising and flourishing at the present time, the season having been unusual in its rainfall. Last year was one of drought, which tested the perseverance of settlers driving the more tender of the "tenderfeet" class back to the eastward, yet most of them remained, while the more diligent and practical secured ample crops. In one instance, a few weeks ago, I saw a crib of corn, which was a part of a crop of eight hundred bushels grown on a homestead in the unfavorable season of 1888, recently taken up and cultivated by a man nearly seventy years of age. Others in the same vicinity grew fair crops of corn and other cereals, potatoes and hay, notwithstanding the absence of rain after the scanty precipitation of early spring.

How are these results accomplished? How is the change produced, from apparent barrenness and desolation, to bountiful productiveness, to a scene

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of rural beauty. It is the result of utilizing the rainfall which was formerly wasted, and the unexpected efficiency of that limited resource, together with the power of man to adapt his methods in industry to unaccustomed conditions, to adapt the processes of agriculture to overcome the limitations of partial aridity. The practice most successful and popular, under these conditions, is found in deep ploughing, with subsoiling, turning the surface soil six or seven inches at least, and stirring the subsoil to an equal further depth, forming a reservoir for the storage of the rainfall to be held until evaporation brings it to the surface, or until the roots of the crops intercept and appropriate it as it rises to the surface.

The question of increasing rainfall gains an affirmative answer from practical cultivators, while the records of the rain gauge fail to make such response. Yet there is an increase, if not in actual rain, certainly in available moisture, because the water which formerly flowed away almost entirely, with almost as much facility as from the back of a duck, making no impression upon the induration of the surface, is almost wholly retained by the loose soil of cultivated lands. As irrigation becomes general, and continuous for years in its seasonal application, there is more moisture in the atmosphere, dews at night are frequent where formerly unknown, and the agricultural value of the atmosphere is enhanced. Practically there is a change in the climate, though the measured precipitation may be no greater than in the period of exclusive Indian occupation of the territory.

While irrigation is an actual necessity, and its results more beneficent in some respects than the abundant rainfall in the east, wherever it can be made available, extravagant assumptions in its behalf, made so frequently, should be avoided. The richest lands, with never-failing supply of moisture, have little value until population and general development of industry have had their influence in enhancing values. There is no such thing as a measure of value by degrees of fertility. There are some of the richest lands on the continent to be obtained, at from $1.25 to $5 per acre, while there are lands in Michigan formerly bogs, which are said to rent for $50 per acre, and others in New Jersey which command a much higher rental. Farmers will not pay extravagant prices for irrigable lands, with water rights, at present, though the changes of the future will advance their value.

The agriculture of the arid region has its peculiar problems for solution, which must be worked out upon the arid plains. After the best methods of cultivation have been determined, there is a wide field of experiment to obtain plants for cultivation best adapted to surrounding conditions.

Those plants will be selected which endure the ardent sunshine, the deficient moisture of this region, the tap rooted plants which are able to go down to seek the moisture, which as by an instinct of self-preservation seeks with instant urgency the underground channels and reservoirs, escaping dissolution by the process of evaporation under the fierce rays of the summer sun.

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The capabilities of this great region for agricultural production are not yet appreciated. It will require time, skill, invention and perseverance to reach the ultimate and highest results. When reached, however, I am sure they will put to shame the expectation and faith of the present time.

The arid belt is to become a great manufacturing region. It has exhaustless mines of tin, copper, quicksilver, iron and other metals: gold and silver; soda and sands for glass; a limitless supply of coal for power and heating; and railways for easy distribution to the Pacific coast on one side and the great central valleys on the other. With irrigation directed and controlled by the government, and carefully guarded against the abuses of monopoly in land or water, there will be large areas in agriculture, yields heavy and sure from a soil fertile to excess, ample production for the supply of a dense population. Such is its certain future, but the development will be quicker, more beneficent, conserving better the rights of the working men whose share in the results should be made absolutely secure, if the irrigation system should be promptly constructed and surely controlled by the general government.

INUTILITY OF THE DESERT LAND ACT. By J. RICHARDS DODGE, Washington, D. C.

[ABSTRACT.]

THE land laws of the United States are based on the idea that farms shall be practically free to all citizens. They have been framed in such phraseology, and executed sometimes in a manner so antagonistic to their spirit, that honest settlers have been despoiled of their rights, and others have entered into the fruits of their initiatory labors. In some instances, persons have been called hundreds of miles, at great inconvenience, and subjected to ruinous delays, and to an aggregate expense, which in extreme cases amounts to two or three times the preëmption value of the land, to secure a perfect title to a common homestead claim. A tangle of technicalities has nullified the intended benefits of the law.

But it is not my purpose to indicate all the defects of the land laws, or the practical injustice so often witnessed in the harshness of their execution, but to call public attention to the inutility of the desert land act. It was framed in evident recognition of the fact that the arid lands, the soils useless for general farming, without irrigation, required an enactment essentially different from that which conferred a free homestead in the regions of adequate rainfall, or gave a privilege of purchase at the minimum price of $1.25 per acre. And yet it fails utterly of its intention as to nearly all the area of its operation.

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A glimmering light seems to have been thrown upon the difficulty of irrigating each quarter section, each 160 acres, in the provisions of the law for the right to purchase a whole section, at $1.25 per acre, after the claimant had provided for its irrigation—its reclamation or habilitation as farm land. The purpose, which was the transformation of a desert to a garden, has utterly failed, except as to very limited margins of small streams which have considerable fall, areas so inconsiderable as scarcely to be worthy of consideration.

The streams are deeply embedded, so that irrigation of a single section could only be accomplished by employment of a steam engine, a pump of enormous power, and a system of canals—a plant almost sufficient to furnish water for a town, to be used in the cultivation of a single farm. It is impracticable, and therefore settlement has been delayed, and millions of acres that might be very productive are a waste, capable only of supporting a pair of oxen on a forty-acre tract, with the limitation of the imminent risk of their freezing to death in a hard winter.

The plan was doomed to be a failure. There are only two methods by which the reclamation can be accomplished: the general government can provide the water, keeping the irrigation works in perpetual repair, or capitalists, either singly or in association, must be permitted to acquire the lands, irrigate them, and sell small farms to cultivators, with perpetual water rights. Water rights may be rented by the company providing irrigation; or, better still, may be sold, the settlers themselves forming a coöperative company, charged with keeping the works in repair, and regulating the distribution of the water by the most equitable plan.

The grossest injustice has been done, in certain cases, to those who have taken up adjoining sections, in sufficient numbers to render possible and practicable a local work of reclamation, and expended hundreds of thousands of dollars in engineering works, and paid in full for the land, and then have been met by years of vexatious delay in obtaining a title, while interest has been eating up the investment, settlement has been barred, the state or territory injured in its production, revenues and internal improvements.

Thus, laws theoretically intended to promote settlement became a hindrance to development, an obstruction to cultivation, a fatal bar to progress. Yielding to clamor against monopoly, our lawgivers create a national monopoly of land, not for use, but to hold forever in a non-productive and valueless condition. Thus far the business of building irrigation works, on an extensive scale, has been far from profitable, entailing failures in many instances. Settlers will not pay high prices for irrigated lands, as the cropping possible in primitive settlements, without markets for the surplus, will not warrant it. In the dim and distant future, when population swarms and industry is highly developed, prices will advance; but present settlers cannot pay fifty dollars per acre, or twenty, and they are sometimes slow to offer ten for land with water rights.

It is believed that a better understanding of the problems of irrigation, and the necessity of providing the means of feeding the future industrial

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population of the Rocky Mountain region, will overturn the present policy of repression, and open to settlement immense areas of land, fertile as any the sun shines upon, capable of supporting a dense population, waiting to utilize magnificent resources, which are now without value or possible use, except by the beneficent intervention of a government, which, while in theory offering free homes to all, in practice withholds from settlement a princely domain, dooming it without a change of policy to perpetual barrenness.

OUTLINE FOR A FISHERY CENSUS OF THE UNITED STATES. By CHAS. W. SMILEY, Washington, D. C.

[ABSTRACT.]

THE census of 1890 will be the eleventh general census of the United States. But so far as it relates to the fisheries, it will be only the second of any extent. The fishery census of 1880 covered a very wide range of topics, and from the material collected there have, thus far, been published seven quarto volumes; the matter being not only statistical, but descriptive and historical. The fishery census of 1890 will be strictly statistical and confined to leading features of the industry. The report will not exceed one volume in extent. All collateral inquiry with reference to the progress of fish-culture and the future fishery resources of the country should properly be left to the United States Fish Commission, which has ample means for investigating these subjects.

A fishery census may be divided into two parts, each requiring different treatment:

I. The fisheries proper, including the taking of fish, oysters, etc., and such expenditure of labor and materials upon them as is necessary for putting the product in condition to market or to use as material for manufacture.

II. The manufacture of fishery products, including the operations of smoking, salting, boxing, canning of fish and oysters, etc., and the making oil, guano, whalebone, leather, glue, isinglass, etc.

I. THE FISHERIES.

A. Their geographical extent.

The investigation should embrace an inquiry into the condition of the fisheries on: (1) The Atlantic Coast. (2) The coast of the Gulf of Mexico. (3) The Pacific Coast. (4) The Great Lakes. (5) The minor lakes and ponds, and (6) The rivers.

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B. Objects of the fisheries.

The inquiry should embrace, as objects of the fisheries, the following, in addition to all the food fishes:

(*a*) Pinnipeds: seals, walruses, sea-lions, etc.
(*b*) Cetaceans: whales, blackfish, porpoises, etc.
(*c*) Reptiles: turtles, terrapins, frogs.
(*d*) Crustaceans: lobsters, crayfish, crabs, shrimps, etc.
(*e*) Mollusca: oysters, squid, clams, mussels, etc.
(*f*) Sponges.
(*g*) Marine plants: Irish moss, algæ, etc.
(*h*) Inorganic products of the sea: salt, sand, etc.

C. Topics to be considered.

1. *Fishing-grounds.* An enumeration of the grounds that are visited by professional fishermen, the seasons of the year in which fishing occurs upon each, the quantity of products obtained from each in 1890, are desired. This will include information as to what new grounds have been occupied since 1880. The number of men and vessels visiting each ground is desirable.

2. *Personnel.* It is necessary to ascertain with care the personnel of the fisheries. This includes owners, fitters, professional fishermen (who look to the fisheries for their entire income), semi-professional fishermen (who fish as a business only a part of the time), women, boys and girls assisting in the same. The ages of this class are important, as showing to what extent it could be drawn upon in time of war for naval recruits. The nationality and place of birth of these people are important. From the semi-professional fishermen, it is desirable to obtain statistics of the number of days or months per year during which they fish, or the proportion of their income derived from this industry. It is also desirable to have for each town, village, etc., along the entire coast line (Atlantic, Pacific, Gulf and Lake), the number of men engaged in each branch of the fisheries.

3. *Capital invested.* This will include for each minor division of the coast: (1) Apparatus (vessels, boats, fishing-gear, etc.); (2) equipment or outfit (salt, ice, bait); (3) shore property (outfitting stores, store-houses, refrigerators, ice-houses, wharves, land, vehicles, horses, cattle, steam-power, fish-cars, etc.); (4) working capital (cash, credit-capital, etc.).

4. *Vessels.* In detail, the following facts will be shown respecting the vessels: (1) name of vessel; (2) rig; (3) net tonnage; (4) date of construction; (5) place of building; (6) original cost and present value; (7) present value of apparatus and outfit; (8) kind and quantity of apparatus, including boats; (9) number of crews, nationality, and place of birth; (10) what fisheries engaged in during census year; (11) fishing season (what portion of the year employed in fishing. What other business engaged in during a part of the year).

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5. *Boats.* The items required are: (1) number of sail-boats of less than five tons burden; (2) number of row-boats, canoes, etc.; (3) value; (4) number of men engaged in boat fishery in summer; (5) number of men engaged in boat fishery in winter; (6) number of men engaged in boat fishery all the year; (7) total number of boat fishermen, nationality and place of birth; (8) kind and quantity of apparatus; (9) value of apparatus; (10) fisheries engaged in, what other kinds of business employed in when not fishing. Proportion of time in each.

6. *Fixed Apparatus.*—Under this head will be shown, geographically, and by special fisheries, the quantities and values of various kinds of fixed apparatus, including pounds, floating traps, weirs, fykes, slides, wheels, seines, gill-nets, pots, baskets, etc. The location of these forms of apparatus will, if practicable, be indicated upon charts by the field-agents.

7. *Baits.*—The bait question being a very important one, it is proposed to show the kinds, quantities, and values of—(1) Bait caught by the fishermen at sea; (2) bait purchased from foreign countries; (3) bait exported from the United States; (4) bait used in the fisheries.

8. *Wages.*—This will include total remuneration for services during the year (1889), whether in the form of profits, "shares" or stated wages. So far as possible, the wages paid will be shown, not only for males and females, but by stated amounts per week.

9. *Rent, Taxes, Insurance, Commission, Interest, Freight and Transportation.*—The amount paid for each of these branches of expense should be stated in a form similar to that shown for other branches of industry, in order to enable the public to make comparisons.

10. *Products.*—For each minor division of the coast is required an enumeration of the amount and values (at prices realized by the fishermen) of each and all products of the fisheries. This includes not only fish sold fresh and salt, but for all purposes of manufacture, for bait, etc., all shell-fish, turtles, terrapins, fur-seals, sponges, etc.

II. MANUFACTURE.

Concerning the manufacture of fishery products, the following items will be obtained, which, in many respects, correspond with those required concerning other branches of the manufacturing industry:

(1) Name of company, corporation, or individual.

(2) Kinds of products manufactured.

(3) Capital invested (*a*) in land, (*b*) in buildings and fixtures, (*c*) in tools, implements, and means of transportation, (*d*) in machinery, and (*e*) in cash.

(4) The productive forces, including overseers and foremen, and divided into (*a*) males above sixteen years, (*b*) females above fifteen years, and (*c*) children and youths.

(5) Non-productive force, including officers (male and female), clerks, watchmen, engineers, drivers, etc.

(6) The wages or salaries paid to the productive forces.

(7) The wages or salaries paid to the non-productive forces.

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(8) An enumeration of the various kinds and values of the materials consumed.

(9) The amount paid for rent, taxes, insurance, commissions, interest, freight, transportation, etc.

(10) The quantity and value of all products.

(11) The number of months in operation, on full time, on three-quarter time, on one-half time, on one-quarter time, and idle.

(12) The number of hours in an ordinary day of labor, from May to November, and from November to May.

(13) Wages paid per week, and the number of hands employed at each rate, both male and female.

(14) The number of hands employed, and wages paid on piece-work to males above sixteen and females above fifteen years, and to children and youths.

(15) The particulars concerning the power used in manufacturing, such as horse-power, steam-power, water-power, electric, gas, or other power.

The collection of data, which will be for the calendar year 1889, will be commenced in January, 1890, and will be secured by personal canvass, either of special agents drilled for the purpose, or by men selected in each locality for their large acquaintance with the subject. The compilation of the returns in Washington will be pushed forward with great vigor, in order that the results may be issued in Bulletins at the earliest practicable moment, and in order that the full report may be placed in the hands of the printer as early as January, 1892.

THE ABOLITION OF SLAVERY IN UPPER CANADA. By WILLIAM HOUSTON, M.A., Legislative Library, Toronto, Ont.

[ABSTRACT.]

IN 1793 the first Parliament of Upper Canada, in its second session, passed "An Act to prevent the further introduction of slaves and to limit the term of contracts for servitude within the province." The slaves for whose benefit this act was passed had been introduced under the authority of an act of the British Parliament, 30 George III, chap. 27, entitled "An Act for encouraging new settlers." It was passed in 1790, and its avowed object was to enable subjects of the United States, who desired to emigrate to Canada, or other British Provinces, to take with them their negro slaves as well as their household goods and farm implements, provided they obtained a license from the governor of the province they desired to enter. That some slaves were actually brought into Upper Canada under this law is certain, and the threatened evil of slavery attracted the attention of Lieutenant Governor Simcoe and the first parliament of Upper Canada in 1793. The act passed by that Parliament for its

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abolition contained four main provisions. The first prohibited absolutely the further introduction of slaves as such, and made them free on arrival in the province. The second was to the effect that all who were then legally in a state of slavery should remain so until set free by their own proprietors. The third limited the term of servitude to twenty-five years in the case of children born of slave parents after the passage of the act, and made the children born of such infantile slaves free from birth. The fourth required each proprietor, on the enfranchisement of his slave, to give security to his parish or township that the freedman would not become a burden upon it. The immediate effect of this law seems to have been a reduction in the value of negro slaves; and its not very remote effect the entire abolition of the institution. There is no record of any slaves in Toronto later than 1811. It is probable that Lieutenant Governor Simcoe was the instigator of the antislavery legislation, as abolitionism was then active in England from which country he had recently come. This probability is increased by the fact that in his speech from the throne at the close of the session he expressed in strong terms personal satisfaction that by the act he was freed from the duty of giving licenses for the importation of slaves.

ECONOMIC IMPROVEMENT OF TRADE CHANNELS. By Comd. HENRY C. TAYLOR, U. S. N., New York, N. Y.

AGRICULTURAL EXPERIMENT STATIONS. By Prof. W. O. ATWATER, Middletown, Conn.

ECONOMIC ASPECTS OF EDUCATION. By Prof. JOHN EATON, President of Marietta College, Marietta, Ohio.

THE SOCIOLOGICAL POSITION OF FREE TRADE. By Prof. LESTER F. WARD, Washington, D. C.

SOCIAL ECONOMICS. By Mrs. LAURA OSBORNE TALBOT, Washington, D. C.

MANUAL TRAINING. By Prof. C. M. WOODWARD, Director of Manual Training School of Washington University, St. Louis, Mo.

CONCLUDING REMARKS UPON THE ECONOMIC AND SOCIOLOGIC RELATIONS OF CANADA AND THE UNITED STATES. By Col. CHARLES S. HILL, Washington, D. C.

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EXECUTIVE PROCEEDINGS.

REPORT OF THE GENERAL SECRETARY.

GENERAL SESSIONS OF THE THIRTY-EIGHTH MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE HELD IN TORONTO, ONTARIO, AUGUST 28 to SEPTEMBER 3, 1889.

ON WEDNESDAY, AUGUST 28, the first GENERAL SESSION of the Association was held in Convocation Hall in the University Building of the University of Toronto. The PERMANENT SECRETARY called the meeting to order at 10 A. M. and requested the Senior Past President, JAMES D. DANA of New Haven, to take the chair in the absence of President J. W. POWELL of Washington. President DANA then formally opened the proceedings, and resigned the chair to the President-elect, T. C. MENDENHALL of Washington. President MENDENHALL in assuming the duties of his office addressed the Association as follows:—

There has been a long established rule, which, in fact, forms a part of the constitution of this Association, restricting the privileges of the presiding officer. Especially is it a well-known principle of the Association that the talking power of the presiding officer shall be limited. Should it be his good fortune to so discharge his duties as to escape impeachment he will look forward to the next year when a special session will be set aside during which he may express his views on anything he may desire.

To indulge in any lengthy address will be to violate the rules of the Association. You will however, I am sure, indulge me while I embrace this first and perhaps only opportunity of thanking you for the great honor you have conferred upon me by electing me to preside over the American Association whose past has been so rich in performance and whose future is so full of promise. No words of mine can express the appreciation of the honor so conferred.

In conclusion I can only say that it shall be my endeavor to discharge the duties intrusted me in a manner satisfactory to the Association.

Prof. CHARLES CARPMAEL, President of the Local Committee, addressed the Association as follows:—

Mr. President, Gentlemen and Ladies of the American Association for the Advancement of Science:—You have been assembled this morning in order that you may have addressed to you a few words of welcome on this your third visit to Canada and first to Toronto, from those who invited you here. In August of last year, during your meeting in Cleveland, I, as president of the Canadian Institute, had the pleasure of forwarding to you an invitation to hold your next meeting in Toronto. This invitation was

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concurred in by the Minister of Education, the Vice-Chancellor of the University of Toronto, on behalf of the Senate of the University, and by the Mayor on behalf of the City of Toronto. You will be addressed in turn this morning by persons representing each of these bodies. Before calling upon others, it is my privilege, as President of the Local Committee, myself to address to you a few words of welcome. In the name, then, of the Local Committee, I bid you welcome, but I hope that the arrangements which have been made for your convenience and comfort during your stay here will speak a more forcible welcome than any words of mine could do. The committee have done their utmost to make those arrangements as complete as possible, and if—for even with the best intentions we are all liable at times to fail in our endeavors—if in anything you should find that we have not done all that you expected of us, I trust that you will put it down to our inexperience and not to any lack of zeal or earnest desire on our part to do all that we could. Your programme will show what we have been able to do, so on this subject I need not waste your time. All I need say is that the different railway and steamboat companies have offered excursions at liberal rates to almost any part of Canada; we are to have two free excursions, the city will give you more than one entertainment, and some of our citizens also hope to see you at their homes. Now, as I am president of the Canadian Institute, one of our oldest scientific bodies, it dating its birth forty years ago, allow me to say a few words on behalf of our scientific men. We, as men of science, welcome most heartily the American Association for the Advancement of Science into our midst. We welcome you all, collectively and individually, not only those veterans in science who have already done much, whose names are known throughout the scientific world and are even not unknown to those not particularly interested in science, but also those recent recruits, if any such there be among you, whose names are not yet widely known, but who, like those veterans, are striving to add their quota to the general stock of knowledge, and who, we may hope, will one day equal, nay—as knowledge advances rapidly in this age—may one day far surpass the veterans of to-day. We feel that you are all fellow-workers with us in a great cause. We welcome you all, whether citizens of the United States or Canadians, for the American Association for the Advancement of Science is truly American, and is not confined to one section of this great continent. Science, as Lord Lytton says in one of his novels, "cares not a jot for men and nations," and so, although as individuals we may differ on questions political, although as citizens of different countries we may differ as to our respective rights of fishing in certain waters, and, too, on other matters, yet as men of science we are fellow-workers, and our sole rivalry shall be the friendly strife of each trying to outdo others in probing the hidden mysteries of nature.

On behalf of the Government of Ontario, the Minister of Education, the Hon. G. W. Ross, welcomed the Association in the following words:—

It is my duty, on behalf of the Government of the Province of Ontario

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to welcome the Association on the occasion of its thirty-eighth annual session and personally I am very glad of the privilege of doing so, because this annual session promises to be a very great and successful one.

We in the Dominion of Canada are at all times glad to receive among us the representatives of every organization, whether for the promotion of science or philanthropy, who choose our land as their place of meeting, and we are particularly glad on the present occasion to welcome the representatives of the most advanced scientific thought of Canada and the United States, in order that we may profit by the occasion by coming in contact with your members.

Perhaps in no part of the continent where the Association has met is there a greater amount of interest taken in educational matters than in Ontario. Here, when laying the foundations of our school system, we have carefully cast around for a model adapted to our peculiar environments, and we have ultimately come to the conclusion that some parts of the New England system were better adapted to them than any other, and so we have largely copied it in our elementary schools. I think this a fitting occasion to recognize our indebtedness to the representatives of those states who are on the platform in having admitted the cardinal principles of the New England system of elementary and secondary education into the Province of Ontario. In addition to this, we have in Ontario watched with interest the progress of university education and the scientific energy of the United States. We have noticed that progress with some pride, and I shall also admit with some little solicitude; we were proud of the success, but solicitous because the universities of the New England states often enticed away some of our most brilliant men, and having so enticed them, kept them. But, in Ontario, we are always proud of our neighbor's prosperity, although sometimes, too, a little jealous because of the slender endowments which we were able to get for some of our own universities, and we could not but look with some jealousy at Cornell, Harvard and Yale. Not but we were proud of the United States all the time, but we looked on with some hesitation about the consequences to the future of our own education in this province. But I am happy to say that the dark cloud has rolled away, and to assure the American visitors of the Association for the Advancement of Science that education in Ontario is now in a prosperous condition. I am proud to say that within its limits the educational system of Ontario has achieved a great deal. Again I welcome the members of the Association to Canadian soil. Here we are proud of the trophies and achievements which have resulted from the great system of scientific research and education developed in the United States and in Her Majesty's Dominions. Here we are touched with the glow of enthusiasm in behalf of science which the Association has spread over the continent, and here in Her Majesty's Dominion we hope for still further progress. I can assure the associates present that in this province they will find themselves in congenial atmosphere, in the company of men of firmness, perseverance, and I would also say of humility, which is an important quality in scientific research.

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We are always glad in Canada to meet our American fellow-citizens. There was a time in Canada when a visit was paid us by a body of United States citizens inquiring into our scientific condition. I don't think it was more than seventy-five years ago when this company of scientists visited us in a ship, and struck their sails in Toronto harbor. The exhibition of fire-works which they gave us was very disastrous for Toronto, and the only thing which we could do was to give them a similar exhibition in return, so we went over and played upon the cities of Buffalo and Detroit, and made ourselves generally disagreeable all along the line. But I am happy, Mr. President, to say that these days have gone by, and I think that if any invocation were necessary we would on both sides beseech the God of our forefathers to avert such a calamity in the future. The energy of Americans has been demonstrated in the development of their great country, and we are glad of it, because we have a larger geographical area of our own to develop. We are glad to testify to the stability of the American constitution, notwithstanding the opinion of Macaulay to the contrary given fifty years ago. It is then with unbounded joy and satisfaction that we welcome to our shores representatives of the country which has produced statesmen like Washington and Lincoln, poets like Longfellow and Whittier, and orators like Webster, Clay and Sumner. We confer upon you the freedom of the Province of Ontario, a province which is larger than all your New England states, which is enterprising, progressive and partially civilized at least. We, without let or hindrance, confer upon you freedom to fish in our lakes and inland waters, notwithstanding the treaty of 1818, or the three-mile limit—on one condition, that when you return to your home you do not excel in those extraordinary reports of piscatorial adventures which we sometimes hear, even from the professors in our colleges. We give you freedom to botanize in our woods and fields, on condition that you regard the emblematic maple leaf and British oak. And we give you freedom to geologize on our mountains, on condition that you do not make comparisons between your Sierras and Alleghanies and our Rockies, and we give you freedom to mineralize in our mines, on condition that you do not get up a corner and embarrass our Canadian capitalists. And we hope that when you leave our shores you will have found that your stay among us was as merry as a marriage bell, that the time which you passed under the sheltering folds of the British flag was as happily and profitably spent as any corresponding period spent under the stars and stripes of free America.

Mr. William Mulock, M.P., Vice-Chancellor of the University read the following address of welcome, and presented it to the President of the Association:

Mr. President and Members of the American Association for the Advancement of Science:—

The Chancellor, Vice-Chancellor and Members of the Senate of the University of Toronto tender to you their cordial greetings on this your first meeting in the capital of Ontario and welcome you to the halls of the Pro-

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vincial University, where it will be their earnest endeavor to furnish every facility in order to the successful carrying on of the work of the Association. They welcome the members of your Association as representatives of pure science in its grandest aspects and as searchers into recondite truths the mastery of which has already contributed in so many ways to the promotion of the highest practical interests of civilization. They welcome you no less heartily to this seat of learning in the full assurance that the presence of so many of those whose names are associated with the most recent discoveries in science and with their practical application to the arts, the commerce and the social life of nations, cannot fail to give a fresh impetus to studies which here engage the attention of a younger generation, and prepare fresh aspirants for carrying on the same work to new and higher results. With no less cordial greeting they welcome you to this meeting on British soil in a province of the Dominion of Canada, an integral part of that great empire with which the history of your own country is so closely identified, in the confident hope that those who are one in a common lineage with Napier, Bacon, Newton and Locke may continue to be bound together alike by glorious memories, by grand interests of the present, and by lofty aspirations. It is the earnest desire of those who now extend to you their most cordial welcomes, that important additions to scientific truth may reward the labors of all who share in the deliberations of this Association.

His Honor the MAYOR OF TORONTO, Mr. CLARKE, said:—

Mr. President, Ladies and Gentlemen:—The pleasing duty has devolved upon me this morning of extending to you in the name and on behalf of my fellow-citizens a very hearty welcome to Toronto. We recognize not only a very graceful compliment in the visit of so many scientific men to our city, but also feel very highly honored from the fact that this is the first occasion upon which the meeting has been held in this Province. We earnestly hope your stay in our midst will be both pleasant and profitable, and that during your sojourn you may feel, if not at home, at least surrounded by warm friends. We recognize also the very great importance of the work in which you are engaged, the distinguished services rendered, and the advances made in science by your Association. I trust that your meeting on Canadian soil may be even more successful than its predecessors in promoting the objects of the Association and intercourse between those who are pursuing science on both sides of the border, and that it will still widen and broaden your sphere of usefulness. Recognizing, therefore, the importance of the work in which you are engaged, and the value of your time, it would not be proper for me after the admirable addresses delivered by the Minister of Education, the President of the Canadian Institute and the Vice-Chancellor of the University, to say more, and I will merely conclude by again extending to you the heartiest greetings and the best wishes of the people of Toronto.

President MENDENHALL in reply to the various addresses of welcome said: I find it difficult to address at one and the same time the gentlemen

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who have spoken addresses of welcome from both sides of the platform. But I take it as a happy omen for our session that we have been welcomed from both sides, and I take a personal pleasure in responding this morning on the part of the Association for the Advancement of Science to this very generous welcome. I may remark that I only regret that the duty of making this response has not fallen on some one more competent than I am to express the feelings of the members of the Association. My consolation and explanation are that the members of the Association are accustomed, and are able and willing to speak for themselves. I need only say that I can assure you I reflect their sentiments, when I thank you most cordially for your hearty welcome. It is not generally known that the American Association for the Advancement of Science has been carrying on for several years a sort of flirtation with the city of Toronto, and on many occasions, your able and intelligent representatives portrayed to us the advantages of holding a meeting here and though it was our desire to do so we always said no, meaning yes, of course, but not wishing to appear too willing. But about a year ago the day was fixed and here we are greatly to our own satisfaction and I trust to yours also.

Turning to Professor Carpmael, the president thanked him for the terms of his address and also thanked Mr. Ross, Mayor Clarke and Mr. Mulock for their references to the international character of the American Association. The Association should always be referred to in its continental sense and not in any sectional sense of the word. You all know that science is not spoken of as a respecter of parallels of latitude or meridians of longitude or other obstructions of a disagreeable character. Those who fish in its waters fish with absolute freedom and the rewards not the punishments are measured in proportion to the size of the catch. The international character of the Association can best be judged by studying its membership. It reveals the fact that at least a fair proportion, in fact a large proportion, of the members are citizens of Canada, and many of the Canadian members have at various times been selected for the various positions of honor, including the highest. The meetings to be held during the week I trust will not be devoid of interest to the citizens of Toronto, and I take pleasure in cordially inviting you to attend the meetings of the Association, not only in general sessions, but also meetings held elsewhere as indicated in the programme. The sectional meetings are free, and the matters coming up at them allow a wide variety of choice. Thus, if the visitor finds the study of biology too exciting he can have recourse to the more soothing subject of anthropology where he will hear nothing but the truth entire and unvarnished. Thus the members hope in some way to be able to repay the citizens of Toronto for the generous welcome which they have extended, which has no three-mile limit.

The GENERAL SECRETARY announced that the COUNCIL recommend, that morning sessions begin at 10 o'clock, that a recess be taken from 12.30 to 2 P.M., and that a General Session be held every morning except on Saturday; those on Thursday, Friday and Monday mornings to be limited to fifteen minutes.

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These recommendations were adopted by the Association. The Association elected the following named gentlemen, nominated by the COUNCIL to fill vacancies: — H. CARRINGTON BOLTON of New York, *Secretary of the Council*, in the absence of Frank Baker of Washington; JAMES DENTON of Hoboken, N. J., *Vice-President of Section D* in the absence of Arthur Beardsley of Swarthmore, Pa.

It was announced that the COUNCIL had on behalf of the Association accepted the several kind and generous invitations to receptions tendered by the City of Toronto and by the Ladies, as named in the Daily Programme.

Attention was called to the two public lectures arranged for by the COUNCIL to be given in the Pavilion, complimentary to the citizens of Toronto,—one by Mr. G. K. GILBERT of the United States Geological Survey, on the Geological History of Niagara River; the other by Dr. H. CARRINGTON BOLTON of New York, entitled Four Weeks in the Desert of Sinai.

The PERMANENT SECRETARY made several announcements and presented the Financial Report showing that the Association was free from debt,—a more favorable condition than it had found itself in for many years.

After several announcements by the SECRETARY OF THE LOCAL COMMITTEE, Professor LOUDON, the General Session was adjourned for the organization of the Sections.

In the evening the usual GENERAL SESSION was held for the purpose of listening to the address of the RETIRING PRESIDENT, Major J. W. POWELL of Washington. President MENDENHALL, in opening the session, said: — I regret extremely to inform you that Major Powell the Retiring President, to whom you have come to listen cannot be present; particularly as you have been led to expect him from the fact that his photograph has appeared in the public newspapers. It is to be hoped, however, that the Major will outlive any false impressions that may have arisen from it.

Major Powell's absence is caused by the fact that the U. S. Government has lately undertaken to reclaim some of the arid lands of the west and his services as Director of the U. S. Geological Survey were required to superintend the plans for the proposed work of irrigation.

At the last moment Major Powell has written a letter of regret from which I will read a few lines. He says, " Permit me to express through you my sincere wish that the Toronto meeting may be eminently successful and that the proceedings may serve to advance scientific investigation and band together the scholars of the Dominion and the United States in a common effort to advance science." Not having Major Powell with us, we have the next best thing,—his paper on the Evolution of Music—which has been prepared for this occasion and which will now be read by his distinguished colleague in the U. S. Geological Survey, Mr. GILBERT, whom I have the honor of presenting.

At the close of the reading of Major Powell's address (see p. 1 of this volume), President MENDENHALL expressed the appreciation of the Association for the reception tendered this evening, saying this appreciative audience was a tribute of respect to the living representatives of science,

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and the appropriate decorations were a tribute to the long line of scientists who had passed away. He could assure the citizens of Toronto that their reception was highly appreciated and had rarely been equalled in the history of the Association.

Mayor CLARKE expressed pleasure at seeing the large turnout of citizens, and called upon Alderman DODDS to make some announcements.

Alderman DODDS announced that the City Council hoped the following evening to have the attendance of the ladies and gentlemen in the Pavilion, when a promenade concert would be given. They came from the grandest republic of the world's history, and he could assure them that Canadians were as unswerving in their loyalty to the old land as they as citizens of the United States were to their own land. He hoped that their visit to Toronto would be a pleasant one.

THURSDAY, AUGUST 29, 10 A. M. President MENDENHALL in the chair. By order of the COUNCIL the following letter from the Woman's Christian Temperance Union was read.

Toronto, August 28, 1889.

HONORED GENTLEMEN:—The members of the Woman's Christian Temperance Union of Toronto District send greeting.

That your coming together may be productive of great good is the prayer of five hundred women of Toronto.

Signed in behalf of Toronto District W. C. T. U.

MRS. J. TROUTMAN, *Cor. Sec.*
MRS. J. FORSTER, *Rec. Sec.*
MRS. R. MCDONELL, *President.*

14 York Chambers, Toronto.

The LOCAL SECRETARY made the following announcements:—

The Amateur Photographic Association had invited members to visit their rooms in the Medical Council building, corner of Richmond and Bay streets, any time during their stay in the city; the Granite Club, Church street, also offered the privileges of their premises, as also did the Royal Canadian Yacht Club. Any member, apart from the geological section, who wished a copy of the geological map of Ontario, might have one at the Local Secretary's office. The General Session then adjourned, and the reading of papers began in the various sections.

At the GENERAL SESSION on FRIDAY, AUGUST 30, presided over by President MENDENHALL, Professor SEAMAN of Washington presented a resolution relating to uniformity in publishing scientific papers, which was referred to the COUNCIL.

MONDAY, SEPTEMBER 2, 10 A. M. GENERAL SESSION IN CONVOCATION HALL. President MENDENHALL having called the meeting to order, expressed the pleasure with which the Association greeted the many Past

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Presidents in attendance. At no recent meeting had they been permitted to see in their midst so many whom they had honored and continued to honor. Of the seven present, Professors JAMES D. DANA, JAMES HALL and J. S. NEWBERRY, were the three senior presidents of the Association.

The communication from the COUNCIL in reference to Reports of Committees was acted upon as follows:

1. Committee on Indexing Chemical Literature presented a report and was continued.

2. The Committee on International Congress of Geologists reported progress and was continued.

3. The Committee on Anatomical Nomenclature with Special Reference to the Brain reported progress and was continued.

4. The Committee on Physics Teaching rendered its final report at the Cleveland meeting asking to be discharged at that time; no record of its discharge then appearing, the Committee was now discontinued.

5. Committee to apply to Congress for a Reduction of the Tariff on Scientific Books and Apparatus, continued.

6. Committee to memorialize Congress to take steps for the preservation of Archæologic Monuments on the Public Lands, continued.

7. Committee on Universal Language, continued.

8. Committee on Chemistry Teaching reported and was discharged.

9. Committee on Water Analysis reported and was continued.

10. Committee of Conference on organization of a National Chemical Society reported and was discharged.

11. The Honorary Special Agent of Transportation for the Association to act with the Local Committee, Mr. Dudley, reported through the Permanent Secretary and was reappointed. His report was ordered to be read at the meeting on Tuesday morning.

The LOCAL SECRETARY announced that the members of the National Club had much pleasure in placing their rooms at the disposal of the members of the Association during their stay in Toronto.

TUESDAY, SEPTEMBER 3, 10 A. M. GENERAL SESSION in CONVOCATION HALL. President MENDENHALL in the chair.

The GENERAL SECRETARY announced from the NOMINATING COMMITTEE the following list of officers nominated for the next meeting of the Association, and in accordance with the unanimous vote of the Association, cast a single ballot for the entire list, who were thereupon declared elected as follows:

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PRESIDENT.

GEORGE L. GOODALE of Cambridge, Mass.

VICE PRESIDENTS.

A. Mathematics and Astronomy—S. C. CHANDLER of Cambridge, Mass.

B. Physics—CLEVELAND ABBE of Washington.

C. Chemistry—R. B. WARDER of Washington.

D. Mechanical Science and Engineering—JAMES E. DENTON of Hoboken, N. J.

E. Geology and Geography—JOHN C. BRANNER of Little Rock, Ark.

F. Biology—C. S. MINOT of Boston, Mass.

H. Anthropology—FRANK BAKER of Washington.

I. Economic Science and Statistics—J. RICHARDS DODGE of Washington.

PERMANENT SECRETARY.

F. W. PUTNAM of Cambridge (office Salem, Mass.).

GENERAL SECRETARY.

H. CARRINGTON BOLTON of New York.

SECRETARY OF THE COUNCIL.

JAMES LOUDON of Toronto.

SECRETARIES OF THE SECTIONS.

A. Mathematics and Astronomy—WOOSTER W. BEMAN, of Ann Arbor, Mich.

B. Physics—W. LECONTE STEVENS of Brooklyn, N. Y.

C. Chemistry—W. A. NOYES of Terre Haute, Ind.

D. Mechanical Science and Engineering—M. E. COOLEY of Ann Arbor, Mich.

E. Geology and Geography—SAMUEL CALVIN of Iowa City, Iowa.

F. Biology—JOHN M. COULTER of Crawfordsville, Ind.

H. Anthropology—JOSEPH JASTROW of Madison, Wis.

I. Economic Science and Statistics—S. DANA HORTON of Pomeroy, Ohio.

TREASURER.

WILLIAM LILLY of Mauch Chunk, Pa.

AUDITORS.

HENRY WHEATLAND of Salem, Mass. AND THOMAS MEEHAN, Phila., Pa.

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The further report from the NOMINATING COMMITTEE recommending that from the cordial invitations to meet in Washington, D. C., Nashville, Tenn., Pittsburgh, Pa., Louisville, Ky., Rochester, N. Y., Concord, N. H., Easton, Pa. (for 1891), and Indianapolis, Ind., the one from INDIANAPOLIS be accepted, and the date be fixed for the third Wednesday in August [Aug. 20] for the first General Session, was concurred in.

The election by the COUNCIL of seventy-two Fellows was announced as follows:—

Arey, Albert L., Rochester Free Academy, Rochester, N. Y. (85). **B C**
Ashley, Prof. W. J., Toronto, Ont. (88). **I**
Avery, Elroy M., Cleveland, O. (87). **B**
Bailey, Prof. E. H. S., University of Kansas, Lawrence, Kansas (25). **B**
Battle, Herbert B., Director Agricultural Experimental Station, Raleigh, N. C. (83). **C**
Baur, Dr. George, New Haven, Conn. (86). **F**
Bell, Robert, M.D., LL.D., Assistant Director, Geol. Survey of Canada. Ottawa (88). **E**
Bennett, Wm. Z., Prof. Chemistry, University of Wooster, O. (83). **C**
Blake, Francis C., Mansfield Valley, Pa. (29). **C**
Blue, Archibald, Assistant Minister of Agriculture, Toronto, Ontario (85). **I**
Bryce, George, LL.D., Manitoba College, Winnipeg, Manitoba (88).
Burgess, Dr. Thomas J. W., Hamilton, Ont. (88).
Calvin, Prof. Samuel, State University of Iowa, Iowa City, Iowa (87). **B E**
Carpenter, Louis G., Fort Collins, Colorado (82). **A B**
Chute, Horatio N., Instructor of Physics, High School, Ann Arbor, Mich. (84). **A B**
Colburn, E. M., Peoria, Ill. (83). **H**
Cook, Chas. Sumner, Prof. of Physics, Northwestern University, Evanstown, Ill. (86). **B**
Crawford, Morris B., Prof. of Physics, Wesleyan University, Middletown, Conn. (80). **B**
Dawson, Dr. George M., Assistant Director Geological Survey, Ottawa (88). **E**
Ellis, Dr. W. H., Prof. of Chemistry, School of Practical Science, Toronto, Ont. (88). **C**
Ewing, Thomas, jr., Columbia College, New York, N. Y. (86). **B**
Eyerman, John, Instructor in Mineralogy, Lafayette College, Easton, Pa. (83). **C**
Floyd, Richard S., 120 Sutter Street, San Francisco, Cal. (84). **A**
Gaffield, Thos., Boston, Mass. (29). **C**
Galbraith, John, Prof. of Engineering, University of Toronto, Toronto, Ont. (88). **B**
Goff, Prof. E. S., Madison, Wis. (85). **F**
Gray, Thos., B. Sc., Prof. of Dynamic Engineering at Rose Polytechnic Inst., Terre Haute, Ind. (88). **B D**

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Haines, Reuben, Germantown, Philadelphia, Pa. (27). C
Harrington, H. H., Prof. of Chemistry at Agricultural College, College Station, Texas (35). C
Hay, Prof. O. P., Butler University, Irvington, Ind. (37). F
Hill, Prof. Robert T., University of Texas, Austin, Texas (36). E
Horton, S. Dana, Washington, D. C. (37). I
Howard, L. O., Asst. Entomologist, Dept. of Agriculture, Washington, D. C. (37). F
Jacobus, Prof. David S., Stevens' Institute, Hoboken, N. J. (37). D A
Klotz, Otto Julius, Field Astronomer, Dominion Government, Preston, Ont. (38). A
Ladd, E. F., Agricultural Experimental Station, Geneva, N. Y. (36). C
Lloyd, Mrs. Rachel, Ph.D., Prof. of Analytical Chemistry, Lincoln, Neb. (34). C
Loeb, Morris, Ph.D., New York, N. Y. (36). C
Loudon, Prof. J., Prof. of Physics, University of Toronto, Toronto, Ont. (38). B
Macallum, Archibald B., Lecturer on Physiology, University of Toronto, Toronto, Ont. (38). F
McCreath, A. S., Harrisburg, Pa. (33). C
Meek, Seth E., Coe College, Cedar Rapids, Iowa (35). F
Morgan, F. H., Ithaca, N. Y. (35). C
Moser, Jeff. F., Lieut. U.S.N. Coast Survey, Washington, D. C. (28). E
Myers, John A., Prof. of Chemistry, Agricultural College, Oktibbeha Co., Miss. (30). C
Novy, F. G., University of Michigan (36). C
Osmond, I. Thornton, Prof. of Physics, State College, Centre Co., Pa. (33). B
Palmer, Prof. Chace, Ph.D., Prof. of Chemistry, Wabash College, Ind. (38). C
Peters, Edward T., Agricultural Dept., Washington, D. C. (33). I
Phillips, Francis C., Western University, Allegheny, Pa. (36). C
Preston, E. D., U. S. C. and G. Survey, Washington, D. C. (37). A E
Reid, Henry F., Prof. of Physics, Case School of Applied Science, Cleveland, O. (36). B
Robinson, Francis C., Prof. of Chemistry, Bowdoin College, Brunswick, Me. (29). C
Schweinitz, E. A. von, Ph.D., Salem, N. C. (36). C
Selwyn, Dr. Alfred R. C., Director of Geol. Survey of Canada, Ottawa, Can. (38). E
Shimer, Porter W., Easton, Pa. (38). C
Shutt, Frank T., M.A., Dominion Experimental Farms, Ottawa, Ont. (38). C
Smith, Edgar F., Ph.D., Prof. of Chemistry, University of Pa., Philadelphia (38). C
Snow, Benj. W., Cornell University, Ithaca, N. Y. (35). B
Spencer, G. L., Department of Agriculture, Washington, D. C. (36). C

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Stoddard, John T., Prof. of Chemistry, Smith College, Northampton, Mass. (35). C

Taylor, H. C., Commander U.S.N., Poughkeepsie, N. Y. (30). I

Traphagen, F. W., Ph.D., Prof. of Chemistry, College of Montana, Deer Lodge, Mon. (35). C

Trimble, Dr. Henry, Prof. of Chemistry, School of Pharmacy, Philadelphia, Pa. (34). C

Vasey, George, M.D., Dept. of Agriculture, Washington, D. C. (32). F

Waldo, C. A., Prof. of Mathematics, Rose Polytechnic Institute, Terre Haute, Ind. (37). A

Ward, William E., Port Chester, N. Y. (36). D

Willis, Bailey, U. S. Geol. Survey, Washington, D.C. (36). E

Wilson, William Powell, University of Pa., Philadelphia, Pa. (38). F

Winslow, Arthur, State Geological Survey, Little Rock, Ark. (37). E

Wright, Prof. R. Ramsay, Toronto, Ont. (38). F

Wright, Thomas W., Union College, Schenectady, N. Y. (36). B

Youmans, Wm. Jay, 1 Bond St., New York, N. Y. (28). C F H

The GENERAL SECRETARY then read the following resolutions approved by the COUNCIL and they were unanimously adopted.

Resolution in reference to the Maintenance of Timberlands.

Resolved, that it is the sense of Section I that the Association through its Council should appoint a committee to memorialize Congress in behalf of the establishment of a proper administration of the remaining timber lands in the hands of the general government for the purpose of insuring the perpetuity of the forest cover on the western mountain ranges, preserving thereby the dependent favorable hydrologic conditions.

Resolution in reference to the Development of the Natural Resources of the Country.

Resolved, that the several great economics of our country demand careful and just consideration and encouragement by legislative enactments which will aid the scientific development of the natural resources of our country proportionate to the rapidly advancing conditions of our people in industry and science.

Resolved, further, that a committee of five be and is hereby appointed to present these resolutions, and to urge the importance thereof to the President and Congress of the United States, and the Premier and Parliament of Canada, and that such committee be instructed to prepare in proper form any data necessary and to use every honorable and earnest means to accomplish the purpose herein set forth, and that the president of this Association be hereby appointed the chairman of such committee, together with four others whom he shall appoint.

In accordance with above resolutions the following committee was appointed:

T. C. MENDENHALL, Washington, D. C., *Chairman;* E. W. HILGARD, Berkeley, Cal.; C. E. BESSEY, Lincoln, Neb.; B. E. FERNOW, Washington, D. C.; WILLIAM SAUNDERS, Ottawa, Canada.

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Resolution requesting the Congress of the Three Americas to consider the Remeasurement of the Peruvian Arc.

Whereas, the history of geodesy includes no more important page than that relating to the measurement in 1749 of the so-called Peruvian arc, which work was conducted by the French government with the coöperation of Spanish officers, and in magnitude of plan and difficulty of a most serious character it was in its time unexcelled; *Whereas* recent improvements in all the processes incidental to such an undertaking have been so very great, rendering possible a vastly more accurate execution of the work; *Whereas*, it is and has been for several years a matter of deep regret that the one great contribution which the American continent has made to the solution of the problem of the figure of the earth should fall so short of what it should and might be; therefore, be it *Resolved*, by the American Association for the Advancement of Science, that the Congress of the Three Americas about to assemble in Washington is earnestly requested to consider the desirability of undertaking the measurement of this Peruvian arc, to be accomplished by a union of the republics represented. This result is not likely to be reached except through international effort, and this recommendation by the congress would be a fitting and proper act of this first conference of representatives of the New World.

Resolved, that a draft of a memorial relating to a Universal Day be referred for report at the next meeting to the following committee:—

R. S. WOODWARD of Washington; WILLIAM A. ROGERS of Waterville; WILLIAM H. DALL of Washington; CHARLES CARPMAEL of Toronto.

Resolved, that a committee of Section C on Spelling and Pronouncing Chemical Terms be made a special committee of the Association as follows:—

THOMAS H. NORTON of Cincinnati; H. CARRINGTON BOLTON of New York; JAMES LEWIS HOWE of Louisville; EDWARD HART of Easton.

The PERMANENT SECRETARY read a letter covering the report of Mr. DUDLEY, Special Agent on Transportation, announcing that for the next meeting of the Association more perfect preparations to secure reduced rates would be made. The PERMANENT SECRETARY also acknowledged the important aid received from Mr. CALLAWAY of Toronto in suggesting plans for the better accomplishment of the end sought.

The GENERAL SECRETARY announced that the following grants from the income of the Research Fund had been made by the Council:—

One hundred and fifty dollars to Prof. E. W. MORLEY of Cleveland, O., for Measurements on the Velocity of Light in a Strong Magnetic Field.

Fifty dollars to Prof. W. O. ATWATER for experiments to be made under his direction on the Heat of Combustion of certain Vegetable and Animal Compounds.

TUESDAY EVENING, SEPTEMBER 8. The concluding GENERAL SESSION of the Association was held in Association Hall. President MENDENHALL called the Association to order at 8 30 P.M. The PERMANENT SECRETARY,

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Professor PUTNAM, in a few words reviewed the work done during the meeting, and presented the usual statistical report of the meeting. He then read a letter from a lady member of the Association, accompanied by a check for $500.00 which she had generously placed at the disposal of the Council, for the advancement of original research, with the suggestion that a hundred dollars should be added to each of the grants made in the morning. [At the meeting of the Council after the adjournment of the General Sessions, the thanks of the Council were voted to the generous donor and the Permanent Secretary was instructed to carry out the expressed wishes of the donor.]

Prof. F. W. CLARKE from the Committee on Resolutions offered the following:—

Resolved, that we the members of the Association for the Advancement of Science, hereby express our heartfelt thanks to the Citizens of Toronto for the great interest they have shown in the meetings of the Association, their untiring efforts to make the gathering successful, their courtesy to all, and their lavish hospitality.

In particular our thanks are due to the Local Committee, whose admirable arrangements have made this, the third Canadian meeting of the Association, one of the most brilliant of its history. To them we owe the many details of personal comfort upon which the success of the meeting so largely depended. Never has this work been better done, and seldom so well. To them also belongs the credit of the delightful excursions to Niagara and to Muskoka lakes, which have been memorable features of this year's assemblage.

To the authorities of the University of Toronto and the School of Practical Science we are indebted for our place of meeting, and for a completeness in the facilities offered which has rarely been equalled in other cities.

We gratefully acknowledge the attentions shown the Association by the Mayor and City Council of Toronto, and especially their kindness in providing two of the pleasantest entertainments of the meeting—the promenade concert at the Pavilion and the garden party at Government House. To the Government of the Province, as represented by the Minister of Education, we must express our full recognition of courtesies extended. To the ladies of Toronto, the members of the Association are deeply indebted for the private hospitality which has been organized in their behalf. Carriages have been furnished, garden parties and receptions have been given, and all with a tact and cordiality of the most earnest kind. Never in the history of the Association has the social side of a meeting been so charmingly developed. To the Press of Toronto we offer thanks for the thoroughness and fairness with which the reports of the meeting have been prepared, and for the many friendly editorials which it has published, giving voice to the public interest in our proceedings. To the Toronto Amateur Association, the Canadian Institute, the Granite Club, and Royal Canadian Yacht Club we acknowledge the courtesies shown us in giving the members of the Association the privileges of their rooms; also to the railway companies

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for reduced rates of fares, and to the Canadian Express Company for transportation of apparatus and specimens, and to the great North-Western Telegraph Company for the free use of its wires we desire to express our gratitude. Finally, to the many friends who have rendered services so delicately and modestly as to remain themselves personally unknown, we must express our warmest appreciation. Though they cannot be thanked in name our gratitude is none the less perfect and sincere.

In support of these resolutions Professor EASTMAN, of Washington, acknowledged especially the efforts of the Local Committee and dwelt upon the success of the meeting so largely due to their generous provisions.

Professor GOODALE of Cambridge, in adding thanks, paid a high tribute to the University and commended it to the support of the people of the Province.

Professor MORSE of Salem dwelt upon the fellowship in science irrespective of geographical limits.

Professor COMSTOCK of Madison, acknowledged the generous hospitality of the ladies of Toronto, and presented the following communication signed by ladies attending the meeting:—

"The undersigned, ladies attending the Toronto meeting of the Association for the Advancement of Science as active and associate members thereof, desire hereby to express to the Ladies' Local Committee, collectively and individually, their sincere acknowledgments for the many courtesies and kind attentions which have been extended to them during the present meeting; courtesies and attentions, too, which have been as elegant and generous on their part, as they have been acceptable and grateful to us."

Professor PUTNAM of Cambridge referred to the work of the Canadian Institute and expressed the hope that it would be loyally supported in its undertakings.

The resolutions were then unanimously adopted.

Sir DANIEL WILSON in humorous and kindly expressions acknowledged the resolutions on behalf of the University of Toronto.

Hon. G. W. ROSS, Minister of Education, replied on behalf of the Province of Ontario, expressing satisfaction with the result of the meeting in stimulating education, and pleasure that the direction of education had found such warm commendation.

Prof. GOLDWIN SMITH, on behalf of the citizens of Toronto, dwelt upon the kindly feeling between the United States and Canada and the brotherhood of its citizens.

Prof. CHARLES CARPMAEL, Chairman of the Local Committee, replied on its behalf that it had found naught but pleasure in its labors and felt pleasure and satisfaction in the appreciation shown by the American Association.

President MENDENHALL after a few concluding remarks declared the adjournment of the Session.

C. LEO MEES,

General Secretary.

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REPORT OF THE PERMANENT SECRETARY.

FOR the third time the Association has shown its continental character by holding a meeting beyond the political boundaries of the United States, thus proving its right to be called American in the widest acceptance of the term. It may now be expected that at no very distant time a meeting will be held in Mexico, which would prove advantageous in many ways, and add still more to the helpful influence of the Association in the advancement of American science.

Without making any disparaging comparisons, it is only simple justice to state that the cordial welcome given to the members in Toronto has never been surpassed, nor have the local arrangements for the meeting and the care taken of the members often been equalled. The members of the Local Committee were untiring in their efforts, and were heartily assisted by the government of the University and by the Provincial and City authorities. The general impression made upon the members of the Association was that the whole city joined in offering them a continual ovation.

The Queen's Hotel and the University building were the headquarters of the Association, and at both places everything possible was done to aid in the work of the meeting, and to assist the officers in their duties, both by the courteous proprietor and clerks of the hotel, and by the officers of the University; while the Local Secretary with several earnest fellow-workers on the committee were indefatigable in their voluntary labors in all directions.

In addition to the several halls in the great University building, the Chemical Laboratory and the new Biological Building on the grounds of the University of Toronto were used for the meetings of the sections. The morning general sessions were held in Convocation Hall and those in the evening at the Pavilion and at the Y. M. C. Association Hall in the heart of the city.

The partial destruction by fire, on February 14, 1890, of that beautiful structure of stone, the main building of the University of Toronto, containing the principal halls of the University, its valuable Library and its Museum, with many of the special class-rooms and laboratories of the professors, so soon after our meeting, has brought the University of Toronto still closer to the members of the Association who in August last were so cordially welcomed within the walls of the picturesque stone building which in its massiveness seemed destined to stand for centuries. It is a satisfaction to know that the insurance and the grant by the Province will secure the restoration of the beautiful façade of the building and the rebuilding of the interior with many improvements. The city of Toronto, the alumni and friends of the University have also made contributions towards the erection and equipment of other buildings. It still remains, how-

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ever, for the friends of education, everywhere, to make such contributions as they can to the Library, Museum, and other departments, totally or partially destroyed by fire. Certainly there could be no better way of showing an appreciation of the kindness with which the Association was treated during its meeting in Toronto, than by a hearty giving of books, specimens, and apparatus to the University by the individual members of the Association, almost everyone of whom must have some volume or object which would prove of value to the University. All such gifts should be addressed to Sir Daniel Wilson, President of the University of Toronto, Ontario.

While for various reasons it was considered best to begin the meeting in the last week of August, as was determined at the Cleveland meeting, there was a general feeling that had it been held a week earlier the attendance would have been much larger; as it was, 424 members and associates were registered from the following places:—

Toronto, 46; other parts of Canada, 29; New York, 88; Washington City, 49; Pennsylvania, 35; Massachusetts, 25; Ohio, 22; Illinois, 16; Michigan, 16; Iowa, 11; Indiana, 11; Maryland, 10; Connecticut, 10; New Jersey, 8; Wisconsin, 6; Kentucky, 5; Tennessee, 5, Nebraska, 4; Texas, 4; Kansas, 3; Arkansas, 3; West Virginia, 3; Mississippi, 3; New Hampshire, 3; Maine, 2; Missouri, 2; Minnesota, 1; Dakota, 1; Utah, 1; Rhode Island, 1; Louisiana, 1.

Of the 197 members elected at the Toronto meeting, 152 have perfected their membership, also 1 elected at Cleveland; 39 members have paid their arrears and have been restored to the roll, making 192 names added to the roll since the Cleveland volume was published. From the Cleveland list 43 names have been transferred to the list of Deceased Members, 32 members and fellows have resigned and 124 have been omitted for arrearages, making a deduction of of 199 from the list. 2 have become life members; 63 members have been transferred to the roll of fellows. Of the 1956 now on the roll, 247 are at this date in arrears for the Cleveland and Toronto assessments, and 288 for the Toronto assessment alone.

The following is a comparative statement of the roll as printed in the Cleveland volume and in the present volume.

	Cleveland.	Toronto.
Patrons	8	8
Members	1271	1229
Honorary Fellows	1	1
Fellows	689	723
	1964	1956

The report of distribution of volumes was omitted in the Cleveland volume of Proceedings. The following record, therefore, is for two years:

Memoirs, No. 1: sold 1, exchange 1, presented 4.

Vols. 1–35: delivered to members 134; sold 121; exchanges 56; presented 73; returned by exchanges 14; bought back, 8.

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Vol. 36: delivered to members 1560; sold 32; exchanges 233; presented 5; duplicate copies to members 3; returned by exchange 1.

Vol. 37: delivered to members 1629; sold 47; exchanges 234; presented 5; duplicate copies to members 2.

Included in the copies presented is a full set of the publications to the Public Library of Toronto, and another set sent to the University of Toronto since the fire.

Of the 227 titles of papers received, 16 were declined by the Council as not suitable to the Association or for lack of proper abstracts. The 211 accepted papers were read as follows:—In section A 24, B 28, C 21, D 10, E 36, F 34, H 39, I 19. Of these 133 are printed in the present volume, either in full or by abstract, and 78 are mentioned by title only. Of many of the latter, abstracts would have been printed had they been given to the secretaries of the sections before the close of the meeting. In other instances the papers have been printed in full elsewhere. The present volume also contains the address by the Retiring President, the addresses by seven Vice Presidents, and the reports of eight committees. In addition to the addresses and papers recorded in the volume, two public evening lectures were delivered by Dr. Bolton and Mr. Gilbert.

As will be seen by the cash account on the following pages, the current debt of the Association, which has been of a greater or less amount for a number of years, was paid off in full at the time of closing the cash account just prior to the Toronto meeting.

The RESEARCH FUND on Aug. 1, 1889, principal and interest, amounted to,	$4,424.97
Commutations of assessments, 1888–9,	200.00
Gift of a lady member at Toronto,	500.00
	$5,124.97
By vote of the Council at Toronto, $150 was granted to Professor Morley in aid of his Measurements on the Velocity of Light in a Strong Magnetic Field; and $50 was granted to Professor Atwater for experiments under his direction relating to Heat of Combustion of certain Compounds,	200.00
To these grants were added $100 each from the above recorded gift at the request of the donor,	200.00
	$400.00
Leaving amount of Research Fund,	$4,724.97
The GENERAL FUND, Aug. 1, 1889, principal and interest,	$116.53

The Association is thus not only free of debt, but has invested funds as above stated, and is able to make grants of two or three hundred dollars a year in aid of research.

F. W. PUTNAM,
Permanent Secretary.

Salem, Mass., June 18, 1890.

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F. W. PUTNAM, PERMANENT SECRETARY,

Dr. THE AMERICAN ASSOCIATION FOR

1888–89.

To admission fees Toronto Meeting	$ 15 00	
" " Cleveland "	655 00	
" " previous to Cleveland	5 00	
Fellowship fees	72 00	
		$747 00
Assessments previous to Cleveland Meeting	669 00	
" for Cleveland Meeting	3,210 00	
" " Toronto Meeting	798 00	
" Associates, Cleveland	108 00	
		4,785 00
Publications sold	62 81	
Binding	72 20	
Postage and express refunded	1 78	
Incidental receipts	25	
		137 04
Gift of Alex. S. Webb of New York	5 00	
Life Membership commutations	200 00	
Research Fund income	200 00	
		405 00
From a Cleveland friend to balance account		33

$6,074 37

I have examined the above account and

SALEM, MASS., AUGUST 24, 1889.

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IN ACCOUNT WITH

THE ADVANCEMENT OF SCIENCE. Cr.

1889–89.

By 2500 copies Proceedings Vol. 37 (536 pages)		
Composition and authors' changes	$1,012 12	
Paper and press work	967 50	
Printing paper covers and binding 2400 copies	264 00	
		2,243 62
Binding 25 copies Vol. 37, half morocco	25 00	
" 75 " " " cloth	37 50	
Cloth covers, 25	5 00	
Printing wrappers and wrapping 2500 Vols.	34 50	
2750 extra copies of addresses and reports	108 35	
		210 35
Expenses of Cleveland Meeting	221 17	
Constitution and list of members, Cleveland	85 00	
Paid Salem Press through George F. Barker	50	
Express, including distribution of Vol. 37	250 83	
P. H. Dudley for postage and express	2 85	
Postage, stationery and P. O. Box rent	177 85	
Telegram and telephone	4 51	
		436 04
Proceedings bought	4 00	
Printing circulars, blanks, tickets, cards, etc.,	86 71	
Petty expenses	8 28	
Fuel	7 00	
Rent of office	108 00	
Janitor to Aug. 1, 1889	100 00	
		313 99
Grant to F. W. Putnam in aid of archæological explorations, from income of Research Fund		200 00
Salary of Permanent Secretary to Aug. 1, 1889	1,250 00	
" " Assistant " " " " "	500 00	
		1,750 00
Carried to Life Membership Fund		200 00
Paid amount adv. by Perm. Sec'y, 1887–8 account		468 70
		$ 6,074 87

certify that the same is correctly cast and properly vouched.

HENRY WHEATLAND, *Auditor.*

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